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A SYSTEM

OF

HUMAN ANATOMY,

INCLUDING ITS

MEDICAL AND SURGICAL RELATIONS.

BY

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WITH A

SECTION ON HISTOLOGY.

BY

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ILLUSTRATED WITH THREE HUNDRED AND EIGHTY FIGURES

ON

ONE HUNDRED AND NINE FULL-PAGE LITHOGRAPHIC PLATES, MANY OF WHICH ARE BEAUTIFULLY COLORED. THE DRAWINGS BY HERMANN FABER, MOSTLY FROM DISSECTIONS BY THE AUTHOR.

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PREFACE.

THE essentially modern science of Clinical Anatomy may be said to owe its origin to the notable activity which characterized the study of the human body during the last quarter of the eighteenth century. In France, the writings of Portal and Cruveilhier, in Great Britain, those of the first Monro, of William and John Hunter, and of Charles Bell, and in Germany, those of Luschka and Hyrtl attest the fact that the plan of uniting Clinical and Descriptive Anatomy in one volume has the sanction of, if it did not receive its first impress from, the men who have largely contributed to make the science of human anatomy what it now is.

But a more intimate union between anatomical and clinical studies has been advocated of late years by the clinicians themselves. The most exhaustive analyses of subjects which are treated after the method of the general anatomist oftentimes will leave points of structure—when the test of clinical study is applied to them—imperfectly exhibited, since the special lines of practical work will suggest comparisons in health and disease which will be naturally left to the clinician to elaborate.

It is necessary, as Charcot declares, to exclude as valueless all observations on the diseases and lesions of the brain in which the topography of the lesion is not indicated with rigorous exactitude. The student of anatomy who is at the same time a student of neurology is thus induced to examine with renewed care and increased zeal the ground of the anatomy of the central nervous system. As an outcome of this, the researches of representative workers such as Meynert, Wernicke, Türck, and Flechsig have thrown, for the first time, light and meaning upon the minute structure of the brain and of the spinal cord. In like manner, Adams and Hancock became authorities on the anatomy of the foot; Curling, on the anatomy of the testicle; Sibson, on the regional anatomy of the viscera; and Politzer and Urbantschitsch, on the anatomy of the ear, etc. Is it not going to the very heart of a correct anatomical method to follow students such as these, and to learn of them the way in which the facts of descriptive anatomy should be presented? Do not such workers in effect tell us that the interest taken in the study of the structure of the human body is prospective only, the exact value not being determined until the clinical application of knowledge concerning these structures has been stated? If this position be correctly taken, is not the proper basis of anatomical teaching the union of the descriptive and the clinical data at the time when the reader is receiving first impressions of this great subject?

There are, doubtless, many anatomical facts which have no practical application. The number of these, however, is rapidly diminishing; and even in the imperfect record of this book it will be observed that there are few subjects concerning which a clinical comment cannot be made. In the selection of representative cases which illustrate anatomical themes, care has been taken to accept

none in which the facts set forth were not clearly demonstrated; and with this limitation in mind, attempts have been made to present an outline of the clinical biography, so to speak, of each and every part of the economy, and to note, however briefly, the varied and momentous deviations from the normal structure which it has revealed.

The attempt to introduce a modified *nomenclature* such as that proposed by Prof. Burt G. Wilder has not been carried to the extent the author would have desired. The profession is conservative, and no reasonable expectation can be entertained that the nomenclature now in use—with all its absurdities and imperfections—will be materially modified until a congress of teachers, convened for the purpose, agree upon a list of terms which will be introduced into the text-books and which will be employed in teaching.

The main object the author has had in view in using terms which are not in general use was to facilitate the task of describing the structures of the body. There is some prospect that the terms "median" and "lateral" will come into use; and it is reasonably certain that when an observer accustoms himself to such terms he will unwillingly relinquish them. "Internal" and "external" are often used synonymously with "median" and "lateral." But in some relations "internal" might be confounded with the "interior" of the body or of an organ, and "external" with the superficies. Yet "median" and "lateral" are awkward terms when applied to the teeth, and cannot in this instance be employed with advantage. In descriptions of spheroidal figures, as the eyeball, or forms which are derivative of the same, as the auditory labyrinth, the terms "meridional plane" and "equatorial plane" are more appropriate. In like manner the terms "frontal" or its equivalents "coronal" and "sagittal" are becoming more and more frequent in English writings.

In the preparation of the work the author has received assistance from many of his friends, among whom he desires particularly to express acknowledgments to Drs. N. Archer Randolph, J. William White, Chas. H. Burnett, B. Alexander Randall, and George A. Piersol. Dr. John B. Deaver rendered valuable aid in revising the proofs of the last section. Dr. E. C. Spitzka kindly assisted in reading the proofs of the minute anatomy of the nervous system.

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For the opportunity of using the section of the brain shown in figure 94, and those shown in figures 97 to 102—all of which are from preparations of Dr. Schmidt's—the author is indebted to the Committee on the Mütter Museum of the College of Physicians of Philadelphia.

In conclusion, the author wishes to express his lasting sense of obligation to those noble men who sustain the library of the College of Physicians of Philadelphia, and who, by a liberal and intelligent policy, enable its books to be loaned to the Fellows. By the aid afforded through such ruling the author's labors have been greatly facilitated.

PHILADELPHIA, September, 1884.

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ALLEN'S

HUMAN ANATOMY.

HISTOLOGY.

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HUMAN ANATOMY,

INCLUDING ITS

MEDICAL AND SURGICAL RELATIONS.

INTRODUCTION.

IT is the design of this book to present the facts of human anatomy in the manner best suited to the requirements of the student and the practitioner of medicine. The author believes that such a book is needed, inasmuch as no treatise, as far as he knows, contains, in addition to the text descriptive of the subject, a systematic presentation of such anatomical facts as can be applied to practice.

Works on anatomy may be placed in two groups: those written by scientists which have no special application of any kind, and those written by surgeons which have a decided leaning to surgical application. The model for the latter group originated in Europe, where the line is sharply drawn between surgical and medical practice. It requires but little discernment to detect the faulty plan upon which both these varieties of books are constructed. The scientist necessarily lacks clinical knowledge and sympathy; the surgeon lacks interest in all but one class of subjects. A book which will be at once accurate in statement and concise in terms; which will be an acceptable expression of the present state of the science of anatomy; which will exclude nothing that can be made applicable to the medical art, and which will thus embrace all of surgical importance, while omitting nothing of value to clinical medicine—would appear to have an excuse for existence in a country where most surgeons are general practitioners, and where there are few general practitioners who have no interest in surgery.

The author may be allowed to say that, in the performance of his self-imposed task, nothing has been hastily or inconsiderately undertaken. He has been actuated throughout by a sincere desire to produce a useful book. He has subordinated all other tendencies and notions to this end. In occasionally attempting a method of treatment of a subject somewhat different from the one usually accepted, he has not departed from established ways of teaching for the sake of appearing to be original, but for good reasons, as he trusts will appear when the reader compares the text with that of other books on anatomy. The plan adopted is one necessarily encyclopedic. The author has gleaned his materials from every source accessible to him, and, so far from fearing a charge of plagiarism, he will be glad to have the instances noted in which he has had the good taste to appropriate an occasional apt phrase or striking adjective. There is doubtless a greater degree of indebtedness due English works than the author is aware of, since the powerful impressions they have made on his mind must remain unconsciously to influence his style.

By way of introduction to the essential features of the volume, the attention of the reader is invited to the kinds of knowledge of the human body the physician demands.

In the first place, the physician demands an exact acquaintance with the form and construction of the organs of the body. But, inasmuch as an anatomical fact is of little use unless the range of the application of the fact is known, the due connection between the normal condition of an organ and the variation in the condition of that organ within the limits of health will

receive proper attention. Accordingly, the typical description of each organ will be followed by a brief statement of "variations."

In the second place, the physician demands a knowledge of the relations of the parts. This information it is necessary to possess in performing operations and in explaining signs or symptoms. Anatomical relations may be interpreted to be the mutual disposition of those parts which occupy the same neighborhood. The local value of relation has been enforced by the surgeon whose accurate knowledge of each special region is held by him to be of great importance; but the general practitioner cannot appreciate the necessity of keeping up ever refreshened impressions of these regions. The anatomical relations he needs are determined at the examination of the sick, or at the autopsy. While parts in a given region may hold both surgical and medical relations, this need not of necessity be the case. In many instances the medical relations involve parts remote from one another and separated by one or more topographical regions. The former will receive the name of the *topographical* or the *direct* relation; and the latter the *clinical* or the *indirect* relation.

In the third place, the physician needs some account of the uses of the organs. This subject overlaps physiological anatomy. That much only will be succinctly given as may be said properly to illustrate the subject from an anatomical point of view, and at the same time to be free from controversy.

In the fourth place, the physician must have a true conception of the nature and general behavior of morbid processes, and of the manner in which such processes are modified by locality. His comprehension of the changes due to diseased action in a given place must be fairly proportional to his knowledge of the normal anatomy of that place. This subject, which will receive the name of *localization of diseased action*, will be illustrated for the most part by concise statements of recorded cases, in which the essential feature of each case will be emphasized and the bearing it has on the subject treated of clearly shown. The material in these sections is capable of being used by the student in two ways: first, in bringing forcibly to his mind the value of the facts themselves, since cases similar to those quoted may occur to himself after graduation; and, secondly, in lightening the task of remembering important though otherwise uninviting details. In a word, anatomy may thus be made—what unfortunately it rarely is—an *interesting study*.

In presenting anatomical features in explanation of given lesions, or of signs, or symptoms, care has been taken to give the sources of the statements made. It is hoped that the original papers or volumes containing such statements will be consulted whenever this is practicable.

May not a yet more important use be made of these cases? May not a series of such abridgments be available in assisting the practitioner in detecting the significance of obscure conditions in relation to which the underlying facts are anatomical? Should these questions be answered affirmatively, this book, it is hoped, will take a place among the physician's volumes of daily reference. In order to assist in the attainment of this object a copious index of diseases and injuries, in addition to the index of subjects, will be appended.

Among other matters, the book will be found to contain an elaborate description of the tissues; an account of the normal development of the body; a section on the nature and varieties of monstrosities; a section on the method of conducting post-mortem examinations; and a section on the study of the superficies of the body taken as a guide to the position of the deeper structures. These will appear in their appropriate places, duly subordinated to the design of presenting a text essentially anatomical.

DEFINITIONS.

Anatomy is the science that treats of the enumeration of organized bodies, and the description of their structure.

Human Anatomy treats of the anatomy of man.

Comparative Anatomy, as usually understood, treats of the anatomy of all animals excepting man. In a better sense, Comparative Anatomy includes the form and structure of animals as related among themselves rather than as related to man. The term may be also used in speaking of the anatomy of the different races of mankind as compared with one another.

Descriptive or Systemic Anatomy treats of the body as classified by its tissues or organs. Thus, the bones, the muscles, the bloodvessels, the viscera, etc., are severally distinct from one another. Descriptive Anatomy is opposed to Topographical or Regional Anatomy. In this subdivision the body is divided by the relations of its parts to one another into a number of more or less arbitrarily defined regions. Surgical Anatomy is a term often used to designate that branch of topographical anatomy which treats of regions of special importance in the study of surgical operations and of the effects of injury. Medical Anatomy is of similar import to the foregoing, but refers chiefly to the relations of parts as specially considered by the student of clinical conditions as distinguished from surgical.

General Anatomy treats of the composition and general relations of the tissues and organs. Thus, by the general anatomy of bone are understood, first, the composition of the fibrous tissue, the cartilage, and the salts contained in the bone; secondly, the relations that these hold one to another; and, thirdly, the consideration of similar structures or ingredients in allied tissues. The study of the ultimate elements of structure, as resolvable by the microscope, has led authors of late years to speak of this branch of general anatomy as Histology or Microscopical Anatomy. In like manner, the chemical analysis of tissue is treated of under the head of Zoo-chemistry, or Physiological Chemistry.

General Anatomy is opposed to Special Anatomy, which deals with the elucidation of a single part. Comparative anatomists apply this term to the structure of a single animal when no comparison is entered upon. In this sense human anatomy itself is a Special Anatomy.

Morphological Anatomy, or Morphology, is the science of organic form, and treats of homologies and the comprehensive relations of parts, especially those relations indicating zoological affinity. It is often inexactly spoken of as Philosophical or Transcendental Anatomy. It is opposed to Teleological Anatomy, or Teleology, which treats of the adaptations of parts or organs to certain final specific uses.

Physiological Anatomy includes the consideration of the functions of organs, but in a more general sense than teleology. There is no sharply-defined line separating physiological anatomy from physiology or physics. The physiological anatomy of the eye is at once its physiology, which, in turn, can be explained only by reference to the principles of physics as applied to vision.

Morbid Anatomy is the science which treats of the variations in the normal anatomy as determined by diseased action. It is conventionally held to include congenital defects, or gross variations in structure: but these subjects are best included under the head of Teratology.

Practical Anatomy is a term much in use to embrace the special kinds of printed directions best suited to those engaged in dissecting, together with the methods of making anatomical preparations, etc. It may also be said to include the study of human anatomy by dissection in contradistinction to the

study of human anatomy as a branch of general knowledge.

Fœtal Anatomy, or Embryology, treats of the origin and formation of the organs in the embryo. As it is naturally considered in connection with the physiological anatomy of the organs of generation, it is often included under the head of Physiology.

Descriptive Anatomy.—Its divisions are as follows:—

The Bones, or Osteology.
" Joints, or Arthrology.
" Muscles, or Myology.
" Bloodvessels, or Angeiology.
" Viscera, or Splanchnology.
" Nerves, or Neurology.
" Special Senses.

ANATOMICAL NOMENCLATURE.

In this book the word *distal* (following Barclay) will be understood to refer to a point away from the centre of the body; and the word *proximal* to a point toward the centre. For example, the trochlea of the humerus is at the distal extremity of the bone, while the head is at the proximal extremity. The word *central* also refers to a portion of a nerve or vessel which is connected with the centre of the system to which the part treated of belongs. The remaining portion, as opposed to the central, is called *peripheral*. In the case of the bloodvessels the central end is often spoken of as *cardiac*.

When the axis of the body or a limb is understood, the words *median* and *lateral* are often used in describing parts. *Median* means near or related to the axis (median line). *Lateral* means near or related to the surface or periphery, as distinct from median. "Inner" and "outer," "internal" and "external," are words very generally employed in the same sense as median and lateral. They are less exact, however, since they are also used to denote a central in opposition to a peripheral part, as in the contents of a section.

Median and lateral are synonymous with *visceral* (splanchnic) and *parietal*, in describing surfaces of the pleura, pericardium, peritoneum, etc.

A *longitudinal* section is a section cut parallel to the longitudinal axis of the body or limb. It may be made from before backward, when it is called the *sagittal* section (vertico-longitudinal), because it is parallel to the sagittal suture of the cranium; or it may be made from side to side, when it is called *frontal* (vertico-transverse), because it is parallel to the frontal suture of the cranium.[1] The frontal section is, of course, perpendicular to the sagittal section. Some writers restrict the term longitudinal to the sagittal section, in which case the frontal becomes to it a dextro-sinistral transverse. It is in this sense that Charcot uses the latter term. The frontal section of the cranium and contents becomes a true transverse section of the brain, owing to the angulation of the brain with the axis of the trunk. But a frontal section of the spinal cord is a longitudinal section, since it is parallel to the axis of the trunk. With the exercise of a little care in the use of these terms, no confusion need occur.

A *transverse* section is a section cut perpendicular to the longitudinal axis. Thus a transverse section of a limb is perpendicular to the axis of the limb.

A *vertical* section can be opposed only to a transverse as the author defines the word, and may include both the frontal and the sagittal. The term should be restricted to sections made with direct reference to the study in which the vertical position of the part is of importance.

The term *horizontal* is sometimes used to express a section made parallel to the plane on which the organ or approximate parts rest. Thus, one can speak of a horizontal section of the brain and of a horizontal semicircular canal, because these are parallel (or approximately so) to the plane of the base of the skull.

In a transverse section of the parts confined in that portion of the trunk, neck, or head which contains the large vessels Owen has named the structures in relation to the position of the central nervous system and aorta. Let it be supposed that it is desired to describe the parts in a transverse section of the thorax; then the structures *above* the body of the vertebra become *neural*, and those *below* the body become *hemal*, since the former are near the central nervous system as expressed here in the section, and the latter are near the aorta. In the same way the section of the

[1] The terms sagittal and frontal are in general use among German writers. That they relate to the disposition of the cranial sutures is an assumption of the writer. He cannot give the authority for their first employment.

vertebral canal becomes the neural space, and the cavity of the thorax the hemal space. Anything *toward* the neural space becomes neurad; and anything *toward* the hemal space becomes hemad, etc.

Ventral and *dorsal* are terms nearly equal in value to those just given. They more commonly relate to surfaces.

Huxley proposes the terms *epi-axial* and *hypo-axial* to designate the relation of parts to any given axis, either of the trunk or of the limbs. According to this method, the longissimus dorsi muscle is epi-axial to the axis of the spine, while the psoas muscle is hypo-axial to it. The biceps cubiti muscle is epi-axial, the triceps is hypo-axial, etc. In making these distinctions the body is assumed to be prone or supine. The terms *pre-axial* and *post-axial* may be substituted for the foregoing in studying a body, like that of man, in the erect position.

In the naming of organs, it must be acknowledged that little order exists in the employment of terms. The terms are often inappropriate, cumbersome in form, and vague in meaning. They are as likely as not to be applied in a manner at variance with their legitimate use. Authors have multiplied terms to such a degree that there are but few structures which are designated by a single name; and since no custom has fixed the choice to be made in such synonymy, clinical writers are perhaps excusable in consulting their own convenience. Whenever practicable, the terminology used by clinical writers will be preferred throughout this treatise. Femurs will have "heads" and "necks," and convolutions will continue to "ascend" or "descend," as long as practical physicians employ these words in recording their cases. With a view of preventing confusion, the more common of the synonymous terms will be placed in brackets after those adopted by the author. The significance of anatomical terms not in general use is fully exhibited in works readily accessible to the student.

HISTOLOGY.

LYMPH.

OF all the tissues of the human frame, perhaps the lymph is the most important; it is certainly one of the most extensive. Possessing a volume nearly one-third that of the entire body, it surrounds every constituent of the connective framework, and is in close contact with the elementary parts of all organs. It is the ever-present medium of transportation from the highways of the blood to the cell-elements of the body, of the pabulum necessary to their life and function; it is the common carrier of the products both of elaboration and of waste of the great connective-tissue system; and it is the perennial stream, through whose agency the depuration of the blood, during its course in the capillaries, is balanced by a complementary accession.

The morphology of the lymph is all that concerns us in this place. Viewed from this standpoint, the lymph is one of the simplest tissues studied under the microscope; and it is for this reason that we have chosen to begin with it.

Under a high magnifying power, lymph is seen to consist, when freshly examined, of numbers of form-elements, imbedded usually in a clear, colorless, transparent, structureless substance of a fluid consistence (the lymph-plasma). These form-elements may readily change their relative positions in the surrounding medium, by means of currents in the latter, or by means of an individual power of locomotion which seems to be inherent in some. In structure, shape, and dimensions, these forms differ much among themselves, particularly in the warm-blooded animals; and their number in a given volume of the fluid medium, in which they are loosely suspended, varies greatly in different parts of the lymphatic system, according to the many circumstances which influence the density and chemical constitution of the lymph-plasma, as well as the activity of the form-elements themselves.

The great majority of these elements do not differ so much in the general plan of their construction, as in the proportions of their constituent parts. Before speaking particularly of this, however, it should be well understood, that in every collection of lymph there are present in the plasma forms in widely varying numbers representing three general classes of elements: (*a*) minute granules; (*b*) cells consisting of one or more nuclei, and a protoplasmic body; (*c*) forms more or less closely resembling red blood-corpuscles.

a. Minute granules.—There are always present in every 0.03937 cubic inch of the lymph numbers of particles, which, under a magnifying power of 500 or 600 diameters, present the form of very *minute granules;* they are somewhat spherical (sometimes angular), have a gray, opalescent appearance, and are in a state of constant agitation—thus exhibiting the so-called *Brownian movement.* It is the presence of these elementary particles in vast numbers which gives rise to the opalescence of chyle. A more detailed description of them will be given when the constitution of chyle is discussed. In the lymph their number varies greatly in different parts of the lymphatic system; it varies also from one time to another in collections made at the same point.

b. Lymph-corpuscles.—The *characteristic* form-element of the lymph is the so-called *lymph-corpuscle,* variously termed leucocyte, white-corpuscle, or wandering-cell.

Size.—The lymph-corpuscles vary much in dimensions. In warm-blooded animals their diameter ranges, in the thoracic duct, from $\frac{1}{5000}$ to $\frac{1}{2000}$ of an inch, while, in the lymph of the peritoneum, the size of

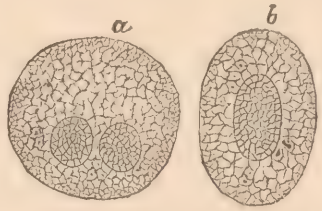
many cells may even reach $\frac{1}{1200}$ of an inch. Their mean diameter is generally less in the efferent than in the afferent vessels of the lymph-glands.

Number.—Their number in a given volume of the plasma has been found to vary quite as widely as their dimensions. Owing to several causes, particularly the viscosity (adhesiveness) of the corpuscles, the enumeration of these elements has always been accomplished with great difficulty, and consequently with much irregularity as to results. Notwithstanding this, however, the data obtained tend to establish, with considerable certainty, the following dicta: 1st. The number of lymph-corpuscles in any given volume of the plasma varies widely in different parts of the lymphatic system. 2d. In the efferent lymph-vessels of lymphatic glands and follicles they are much more numerous than in the afferent vessels of the same glands. 3d. They are usually much less numerous in the smaller than in the larger lymph-vessels of the same course. Indeed, in many locations, the small radicles of the peripheral lymph-capillaries are almost entirely free of lymph-corpuscles. 4th. The small lymph-spaces and lymph-capillaries of the tendons and aponeuroses contain almost none in health, while in the loose connective tissues lymph-corpuscles are much more abundantly present.

In the dog, lymph from the thoracic duct, at one observation, was found to contain 4800 globules per 0.03937 *c. i.*; at another time the number reached 7500 per 0.03937 *c. i.*, while the number of white corpuscles in the blood was 25000 per 0.03937 *c. i.* In the rabbit, the same observer (Ranvier) found in the thoracic duct 11300 per 0.03937 *c. i.*, whilst in the blood of the aorta only 7500 were enumerated.

Minute constitution.—Both nucleus and cell-body consist of a fine network of colorless albumenoid material, which incloses in its meshes a semi-fluid substance, usually also colorless. This network is visible only under very favorable conditions, generally after the action of certain reagents, yet it has been seen in other cells of the economy *in situ natura* during the life of the animal. The nuclear portion of this network has been termed the intra-nuclear, while that of the surrounding cell-body has been named the intra-cellular network; the fibres of the two intercommunicate through the limiting membrane of the nucleus. The opalescent or finely-granular appearance of this and of the preceding class of white cells or lymph-corpuscles is entirely due to the optical effect of the fine fibres forming the network. Seen in optical transverse section these minute fibres appear as fine grayish granules, and at the nodal or crossing points, resemble dots of similar aspect, the minute intermediate spaces seeming more brilliant. It is this finely-mottled appearance which has suggested the use of the term "*finely granular*," universally employed in describing some cells, for in many healthy living cells there are really no granules to be found. *a*, Fig. 1, represents very fairly the networks already referred to. The drawing also very well shows the difference in the closeness of the two reticula. By reference to the figure it will be readily observed that the meshes of the intra-cellular network are much wider than those of the intra-nuclear reticulum. It can now be readily understood that the semblance of a granule or pseudo-nucleus in the cell-body, or of a spot or pseudo-nucleolus within the nucleus, may be produced by means of a condensation or contraction of this reticulum at any point.

Fig. 1.



a. White blood-corpuscle, showing an intra-cellular and an intra-nuclear reticulum. *b*. Elliptical colored blood-corpuscle, showing similar reticula. High power. (*Klein.*)

Varieties.—For convenience of description *lymph-corpuscles* may be divided into three classes—the extreme forms of each class, however, gradually shading off into those of the others—as follows:—

1. In every specimen of lymph there are to be found *small colorless corpuscles*, more or less spheroid in shape, composed of a single roundish nucleus, surrounded by an exceedingly small protoplasmic body. In their construction these small cells do not visibly differ from those of the next succeeding class, except in the relative proportion of nucleus to cell-body. They are present in numbers varying according to the location from which the lymph may be obtained. In the thoracic duct their number is about equal to the elements of the second class, while in the efferent lymph-vessels of lymphatic follicles or glands they are much more numerous, and in the afferent vessels of the same glands much less numerous than the larger lymph-corpuscles. In the lymph-glands themselves these small colorless corpuscles preponderate in the medullary portion, while, on the contrary, the larger cells far outnumber the smaller in the cortical portions. Because of the very small protoplasmic body of these cells they have frequently been described as free nuclei. Their diameter is often not more than $\frac{1}{3000}$ of an inch.

2. A *larger finely granular cell*, with one nucleus about the size of that of the preceding variety, or with two or more smaller ones, and with a surrounding cell-body of much greater extent, more or less spherical in outline when at rest, and composed of a

minute structure apparently identical with that of the preceding forms, may be considered to represent the second class of lymph-corpuscles. In the thoracic duct, and in the afferent vessels of lymph-glands, their diameter often reaches $\frac{1}{2500}$ of an inch, while in serous cavities it not infrequently measures $\frac{1}{1200}$ of an inch. The cell consists essentially of two parts, nucleus and cell-body. The nucleus, whether there be one or more contained within the body of the cell, is usually spheroid, vesicular, and possesses a limiting membrane of double contour. When single, the nucleus is about $\frac{1}{5000}$ of an inch in diameter. During life, the nucleus is, as a rule, invisible, being masked by the natural slight opalescence of the cellular body surrounding it.

3. The intra-cellular reticulum of the lymph-corpuscle may contain, in its meshes, besides a colorless hyaline semi-fluid substance, real collections of colored or highly refracting material—genuine *granules*. The cell is then called *a granular cell*. The size of these granular cells may equal or exceed the dimensions of the finely-granular corpuscle, but they are present in the lymph in much fewer numbers than the latter. The granules are not distributed evenly throughout the cell, but may be more or less grouped in various portions. Their predilection is for the body of the cell. This is so strong, indeed, that when seen during life, light areas are often observed of considerable size wherein scarcely any granules are visible. These lighter areas generally correspond to the position of the nuclei when the cells are motionless.

The lymph-corpuscle is destitute of an enveloping membrane. When living, its substance is soft and gelatinous, and extremely free to assume any shape which extraneous or inherent forces may direct. Living lymph-corpuscles, when removed from the animal which they inhabit, and observed under conditions of heat, surrounding fluids, gases, etc., which are as nearly as possible natural to them, evince their vitality in numerous ways, and for longer or shorter periods.

Movements. — Many of these are contractile, and when watched sufficiently long and close, exhibit various phenomena of an individual motion, which, when energetic and protracted, may ultimately result in cell-multiplication or locomotion. This contractility seems to reside in the fibres which constitute the reticulum, the fluid and the granules which may be suspended in it having only a secondary or passive motion. It appears also that the intra-cellular reticulum is usually much more powerfully active in the various movements of the cell than is the intra-nuclear network. Even a movement which accomplishes the division of the nucleus, but stops short of complete cell-division, may be effected almost entirely through the agency of the intra-cellular network. Yet the intra-nuclear network is by no means entirely passive. It possesses and exercises a measure of moving power, for certain reliable observers have seen spots or nucleoli move within the nucleus when the cell presented no other movements. During the contractions and expansions of the reticulum the fluid and the suspended particles contained in the meshes are set in motion, and currents more or less limited are thus produced. In this way suspended particles, whether elaborated in the cell or imported thither, may move from place to place, while the invisible contraction or expansion of the reticulum may have a location in the cell quite different from that of the movement of the visible particles.

The lymph-corpuscles of the second and third class are, *par excellence*, those cells of the lymph which exhibit active movements. The small colorless corpuscles, having only a very thin cell-body around the nucleus, and consequently a very small amount of intra-cellular network, as a rule, show very feeble movements, or none at all. When the fresh lymph of a batrachian or mammalian animal is, immediately after extraction, placed in a moist chamber and properly prepared for examination under a high power of the microscope, at first, the colorless corpuscles are, more or less, perfectly globular, and so opalescent that the nucleus cannot be seen. Presently, if the temperature of the lymph be kept sufficiently near that normal to the animal from which it has been taken, some of the *finely granular*, as well as many of the *granular* corpuscles are seen to put forth from one or more portions of their surface hyaline masses, which may persist indefinitely, or be at length withdrawn. These masses, at first hyaline, or, in the case of the granular corpuscles, free from granules, soon, in a greater or lesser part of their area, present the same optical appearance as does the body of the cell. They may then increase in size until perhaps half the volume of the cell has, so to speak, flowed into them. After or before this stage of alteration of form has been reached, one of two things may happen. The substance of the projection or bud may sink back again into the original body of the cell, which may then present its primary form, to be perchance subsequently altered again by similar manœuvres; or the remainder of the cell-substance may continue to pass into the projection, until the latter has completely absorbed the former. In the latter case, it is evident that the location of the cell has been changed. In

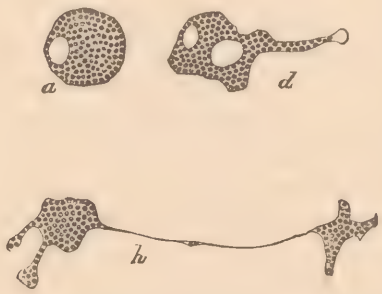
this manner the lymph-cells may slowly move from place to place. After a considerable portion of the substance of the cell has passed into a bud or projection, the two main masses may increase the distance between their centres by a lengthening out and thinning of the pedicle which unites them (see Fig. 2). Subsequently the newly-moulded mass may still flow back into the original cell, as before suggested, or it may draw the original or mother mass into it, or the two masses may continue to separate until the uniting bond becomes so fine that it breaks, when the two become independent individuals, each endowed with the characteristics of the original cell. This is one of the modes of multiplication which the student can readily follow. Instead of one such budding mass, two or more may sprout from the original cell-body, and experience the various changes already mentioned. Figs. 2 and 3 very fairly represent the out-

Fig. 2.



White Corpuscles (or Lymph-cells) undergoing division, and active movements. High power. (*Carpenter.*)

Fig. 3.



A Granular Corpuscle of Newt, showing changes undergone in fifteen minutes. High power. (*Klein.*)

lines which the finely granular and the coarsely granular corpuscles present at various stages of their alterations, although they are drawn from white blood-cells. The structure of the cells, however, is not portrayed with equal truthfulness, the granular aspect of the granular corpuscles being exaggerated, while the nuclei of the finely granular cells are much too prominent. The changes in form already mentioned are essentially those of budding or gemmation. At the same time that they are transpiring the original nucleus, if there be but one, may suffer division either by fission or gemmation. Usually each large bud draws into it a nucleus, if the budding is to result in cell-multiplication.

The lymph-corpuscle, instead of putting out buds, may present a constriction in the cell-body, which may progress until both the nucleus and cell are cut into two. Thus, two new cells may be the result of division by scission.

The portion of the cell cut off from the original mass in the two ways above indicated may vary much in size. Unless the new mass contain a nucleus it cannot be regarded as a complete cell. Whether such a nucleated mass be capable of development into a perfectly formed corpuscle endowed with powers of reproduction and of ulterior usefulness is a question which remains open. In every specimen of lymph there are such masses to be found, varying greatly in size, but never presenting large dimensions.

The movements above considered, because of their resemblance to those of the uni-cellular animals called amœbæ, were termed by Max Schultze *amœboid movements*, and the jelly-like substance of which the cells are composed, on account of its general resemblance to the material of certain vegetable cells, received the name of *protoplasm.*

Degrees of vitality.—The various colorless elements of the lymph appear to be endowed with different degrees of vitality and of activity. In every collection of fresh lymph properly prepared for microscopic examination, there are some colorless corpuscles which, as long as the examination is continued, remain unchanged, and, of those which show signs of life, some present much more sluggish movements than others. Of the immobile cells, those which show a sharply defined nucleus, or two or more of the same kind, or which contain great numbers of fatty molecules, may be considered moribund or perfectly inert, and perhaps already advanced in the process of disintegration. Ranvier regards these as identical with varieties of pus-corpuscles (see Fig. 4). Those which still preserve their opales-

Fig. 4.



Pus-corpuscles.—1, *a*, *b*, in water; *c*, *d*, *e*, after the action of acetic acid. 2, division of nuclei—*a*, *b*, division progressing; *c*, *d*, more or less complete. (*Virchow.*)

cent finely granular appearance, and their nucleus partly or not at all visible, may, for periods, remain in a dormant state, and be capable of being awakened therefrom by the action of a sufficient stimulant.

Chemical and physical influences.—Of the agents which variously affect the lymph-corpuscles, some of the chief are heat, moisture, oxygen, acids, and electricity. Whilst a certain degree of heat is essential, not only for the manifestations of amœboid

movements, but also, even for the existence of life in the corpuscles, yet, on the other hand, the temperature cannot pass above a certain elevation without endangering the life of the cell. The two extremes of heat within which the amœboid cells are active, seem to be for the warm-blooded animals about 70° and 106° F. The temperature of the lymph can be brought much lower than 70° F. without necessarily destroying vitality. Indeed, these cells have been seen to show every phenomenon of life after freezing and thawing. Protracted lowering of the temperature below the extreme, however, is certain to induce the death of the cellule. The nearer the heat approaches the highest extreme the more rapid become the amœboid movements until the limit is reached, when they suddenly cease in the destruction of the life of the element, the crisis being manifested by the retraction of the amœboid prolongations, the resumption of the spherical form of the corpuscle, and the distinct appearance of the nucleus, and of the granules contained in the body of the cell. The highest extreme of temperature cannot be surpassed without resulting in death.

Not only is warmth necessary for the life and activity of the lymph-corpuscles of warm-blooded animals, but, according to Ranvier, oxygen seems also to be essential. When the cells are deprived of it, they become sluggish, asphyxiated, and finally die. Amœboid movements of the cells are excited by it, and sluggish corpuscles in which the vital activities lie dormant or in suspense are resuscitated and put into vigorous motion. As will be seen below, the lymph-plasma, especially in the larger trunks, contains only a minimum of oxygen, a circumstance in harmony with the known comparative inactivity of the lymph-corpuscles in the passage-ways of the lymphatic system. When floating in a medium nearly devoid of oxygen their activities being, as a rule, dormant, their form is generally spherical, and their movements are mostly only passive. When it is remembered that it is by means of their amœboid movements that they apply themselves to surfaces, creep along, and pass through them, and that it is upon these movements their stickiness or so-called *viscosity* depends, it will be readily understood how important for the economy is the fact that in the great lymphatic system, where the fluids move so slowly, and where, consequently, sticky elements could readily crowd together and obstruct the channels, one of the essential stimulators of the amœboid movements, oxygen, should be almost entirely wanting.

A sufficient fluidity of the elements themselves and of their surrounding medium is also necessary for the lively movements of the lymph-corpuscles. An increased specific gravity of the plasma retards, while, *vice versa*, within certain limits, a lowered specific gravity accelerates the amœboid movements. By the addition of water, in sufficient quantity, to the medium in which the lymph-corpuscles float, the cellular protoplasm is swollen and made more transparent, the nucleus becomes distinct, finally the granules which may be contained within the cell assume the Brownian movement and the cell dies. These various phenomena of the death of the cell become more marked and follow each other in more rapid succession if an acid be added to the water.

Viability. — The viability of lymph-corpuscles is great. Under favorable conditions of heat and oxygen and other surroundings, they readily live a long time without the organism. When properly preserved they have given evidence of life hours, days, and even weeks after extraction from the animal.

Lymph-corpuscles exposed in the moist chamber to the action of vapor of iodine become fixed and killed the instant the vapor reaches them. Most of the cells assume a yellow tint, while the nucleus and granules become distinct. According to Ranvier, a few cells are stained mahogany-brown, the color characteristic of glycogenic matter. This author states that, in these cells the glycogenic matter is diffused throughout the whole of the element. It may be extruded from the cell in the form of drops, and if the action of the iodine be sufficiently prolonged these drops may fuse together and form a halo or atmosphere around the cell of a brown-mahogany color. The presence in the lymph-corpuscles of this matter explains why chemical analyses have revealed the presence of sugar in the lymph.

Absorption.—By means of their amœboid movements, lymph-corpuscles possess the faculty of drawing into themselves minute particles with which they come in contact. They have been seen also to expel such particles from within their interior. Thus they may absorb minute particles at one location, carry them for awhile in their meanderings, and subsequently discharge their cargo at a distant point, to be absorbed perhaps again by another living cell. This circumstance has an important bearing upon the positiveness of deductions, respecting the nature of inflammation, which have been drawn concerning the identity, in the tissues outside of the bloodvessels, of lymphoid and other cells containing in their interior minute foreign particles which at some point have been injected into the blood-stream.

Lymph-corpuscles may become loaded with absorbed innocuous minute foreign particles without having their activity seriously impaired. Many lymph-corpuscles are found which inclose in their interior various substances naturally met with in the course of their circulation, as for example fat drops, granules of blood-pigment, fragments of red blood-globules, and sometimes even small red blood-disks. Those cells which contain small red blood-disks have given rise to much dispute among physiologists, some believing that the blood-disks are formed within the cell, others claiming that the red disks reach their singular location in the same manner that other extraneous particles become absorbed. From their supposed power of elaboration of certain products, which may be discharged either as waste material or as matter to be used by other elements of the economy, Ranvier has suggested that the lymph-corpuscle is a *uni-cellular wandering gland.*

c. Red corpuscles.—Another element constantly found in the lymph is the red blood-corpuscle. It is usually met with only in small numbers when the lymph has been very carefully extracted. Its source may be traced to diapedesis from the blood-capillaries, which doubtless is to some extent a never-ceasing means of supply. But it is also possible that many may be the outcome of a new formation somewhere within the lymphatic system.

Plasma.—The plasma of the lymph, as has already been stated, is, when fresh and normal, a colorless transparent substance of fluid consistence. According to Chevreul, a thousand parts of the lymph of a dog yielded, of water, 926.4; of albumen, 61; of fibrin, 4.2; of salts, 8.4. In estimating the gases in the lymph, Hammarsten found in 3.527 ounces of fluid 1.664 cubic inches of gas, of which .054 *c. i.* were nitrogen, .016 *c. i.* oxygen, and 1.594 *c. i.* carbonic acid. In consequence of the fibrin-elements which it contains, the plasma of the lymph soon coagulates into a gelatinous mass when collected. If set aside for a while, this mass separates, like the blood-plasma, into two portions, the serum and the clot, which latter, in its elements, does not differ microscopically from that of the blood.

CHYLE.

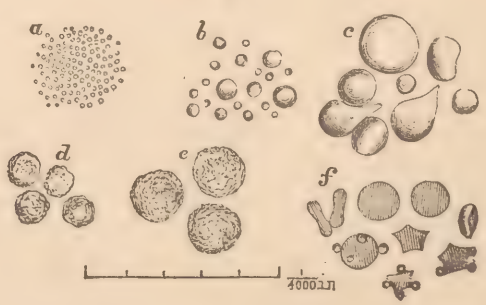
The fluid collected by the lacteals, transported through the mesenteric lymphatic vessels and emptied into the thoracic duct with the lymphatic fluids from other locations, is lymph which contains elements already described. In the intervals of digestion, it contains many more *minute granules* (*a*, Fig. 6) in a given volume of fluid than the lymph usually carries, but during digestion the number of minute particles is so enormous that, when viewed by the naked eye, the chyle presents an opalescent appearance, which is entirely due to their increased numbers. The most minute of them usually exhibit the Brownian movement. These granules do not consist solely of fat, as some have contended, but they possess a protoplasmic body which forms an envelope or frame for the load of fat which each of them holds. Under a high power of the microscope, after treatment with the proper reagents, each minute particle is seen to consist of a small fat-drop imbedded within a mass of protoplasm, which envelops it as a thin shell. Acetic acid added to the fluid dissolves these delicate protoplasmic envelopes and sets free the fat-globules, many of which then run together to form larger fat-drops (*b*, *c*, Fig. 6). When a collection of chyle is placed in a flask, and

Fig. 5.



Molecular Base and Corpuscles of Chyle.—At *a*, from a lacteal on the intestine; *b*, from a mesenteric gland; *c*, from the receptaculum chyli. From Man. (*Carpenter.*)

Fig. 6.



Contents of Chyle.—At *a*, primary molecules of chyle; *b*, secondary molecules of chyle; *c*, fatty globules; *d*, chyle-corpuscles; *e*, pale cells; *f*, red corpuscles. (*Carpenter.*)

after the addition of ether is set aside for a day or two, there is found at the bottom of the vessel a deposit which consists of lymph-corpuscles and minute granules. The latter have retained their original globular or angular shape, have become more translucent, and have been entirely deprived of their fat.

BLOOD.

Like the lymph, the blood, when naturally flowing, consists of a colorless transparent fluid plasma, in which freely float numerous and varied minute animal forms. The proportion of the volume of these form-elements to that of the plasma is about as follows: In 1000 parts of blood there are—

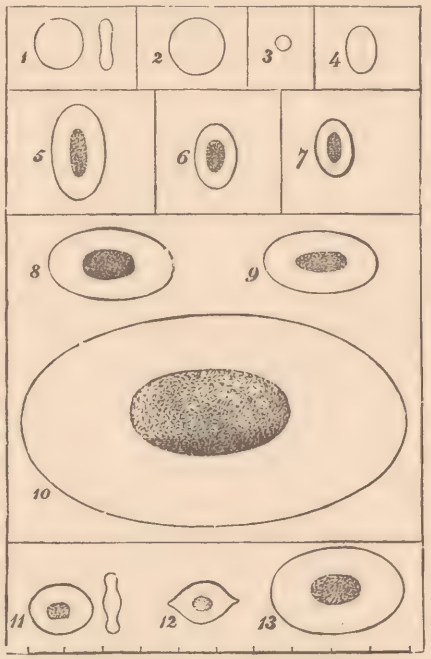
Water	790.
Globules	127.
Proteid substances	73.
Fatty matter and salts	10.

Besides the fluids and solids above enumerated, the blood is always more or less charged with gases, of which carbonic acid, oxygen, and nitrogen are the chief. The capacity of the blood for the absorption of oxygen is peculiarly great, being more than eight times that of water. Whilst the oxygen of the blood is almost, if not quite, exclusively held in the red corpuscles, the carbonic acid is united with the plasma.

Number and size of red corpuscles. — By far the most numerous and most important form-element of the blood of vertebrate animals is the red blood-corpuscle, or red blood-disk. We learn from the enumeration of Malassez, that in cartilaginous fishes the number of these elements ranges from 140,000 to 230,000 per .03937 cubic inch (a cubic millimetre); in the osseous fishes the number varies between 700,000 and 2,000,000 per cubic millimetre. The same investigator places the number of these corpuscles per *c. m.* in birds at 1,600,000 to 4,000,000, while the extreme numbers per *c. m.* in the mammiferæ are recorded at 3,500,000 and 18,000,000. We have the authority of the same writer for the statement that the mean volume of the corpuscles is almost always in inverse ratio to their numbers. This proposition is not absolute, however, for a small number of the colored corpuscles may not be entirely compensated by an increase in the volume of the corpuscle.

By consulting Fig. 7 and the table subjoined, the enormous difference in size, as well as in shape, of the colored corpuscles of the blood of different vertebrate animals can be readily appreciated. It will be noticed that the long axis of the red corpuscle of the proteus is recorded in the table as $\frac{1}{400}$ of an inch, a magnitude sufficiently large to be appreciated by the naked eye under favorable circumstances. Yet the colored blood-disk of the *Amphiuma* (Congo eel) is quite one-third larger still.

Fig. 7.



All the corpuscles here shown are drawn to the uniform scale, at the bottom of the wood-cut, of 1-4000th of an English inch, and the measurements are expressed in vulgar fractions of that inch. T. D. signifies transverse diameter; L. D. long diameter; S. D. short diameter. (*Gulliver.*)

		T. D.	L. D.	S. D.
	MAMMALIA.			
1.	Red Corpuscle of Man, seen on the flat surface and also on the edge; thickness 1-12400	1-3200		
2.	" of Elephant	1-2745		
3.	" of Musk Deer	1-12325		
4.	" of Dromedary, thickness 1-15337	. . . .	1-3254	1-5921
	AVES.			
5.	" of Ostrich	. . . .	1-1649	1-3000
	" Nucleus of Ostrich . . .	. . . .	1-3200	1-9166
6.	" of Pigeon	. . . .	1-2314	1-3429
7.	" of Humming Bird . . .	. . . .	1-2666	1-4000
	REPTILIA.			
8.	" of Crocodile	. . . .	1-1231	1-2286
9.	" of Python	. . . .	1-1440	1-2400
10.	" of Proteus	. . . .	1-400	1-727
	PISCES.			
11.	" of Perch	. . . .	1-2461	3-3000
12.	" of Pike	. . . .	1-2000	1-3555
13.	" of Shark	. . . .	2-1143	1-1654

According to the statements of various observers, the mean number of the colored corpuscles in the blood of man may be regarded as varying in health between four and five millions per cubic millimetre. The counts of the corpuscles made upon the blood of the same individual appear to vary considerably, according to the location whence the blood is obtained. It seems, however, to be pretty well established that in any portion of the economy where there is a condensation of the plasma of the blood by loss of fluid,

either from evaporation, or from excretion, or the like, there is usually to be found in the blood of the part an increased number of corpuscular elements. On the contrary, under opposite conditions, the number of red globules has usually been found to be below the mean. In the left heart, and in the large arteries of the limbs, the number of globules is identical, but in the arterioles it is increased. The venous blood of the skin, where evaporation is rapidly going on, and the venous blood of the kidneys, where excretion is taking place, is much more rich in red blood-disks per *c. m.* than is the blood of the corresponding arteries. In the interim of *digestion*, the mesenteric venous blood is richer in red cells than is the arterial blood, yet less rich in this respect than the blood of the cutaneous veins. During digestion, however, there are fewer red corpuscles per *c. m.* in the mesenteric veins than in the supplying arteries. There is, of course, in the latter case an accession of fluid in the veins by absorption of the intestinal juices. The emptying of the lymph into the blood-stream at the mouth of the thoracic duct, also causes a lowering of the number per *c. m.* of the red corpuscles in the blood-current on the proximal side of that point. The splenic vein is much richer in red disks than is the artery. The subhepatic veins have fewer red cells per *c. m.* than have either the portal veins or the ascending cava. There is in the liver a probable destruction of red globules.

Besides these, so to speak, local variations in the number of colored corpuscles in a given volume of the blood, there is, perhaps, a physiological mean variation for each individual, as well as a difference in individuals dependent upon the conditions of sex. According to some investigators, there would also appear to be slight fluctuations in the mean volume of the colored cells without a marked disturbance of health, as well as differences in the intensity of the coloring matter of the corpuscle. The same authors claim that certain abnormal states of the economy show these fluctuations in a more or less marked degree. Thus Hayem declares that in *chronic anæmia* the mean dimensions of the red globules are always lessened. 100 globules of anæmic blood may correspond in volume to less than 80 healthy globules. At the same time, the intensity of the coloring matter of the corpuscles may be lessened one-quarter or one-half.

The fresh fluid blood of vertebrates, as is well known, presents to the naked eye, when seen by reflected light, and in considerable quantity, a homogeneous opaque aspect and an intense red color. It is opaque to the naked eye for the same reason that an emulsion of oil is opaque. When spread out in an extremely thin layer, however, and examined under a very high magnifying power by transmitted light, the fluid or plasma of the blood is seen to be perfectly transparent, colorless, and structureless. The form-elements which float in it in enormous numbers are of three general classes: colored cells, colorless cells, and minute free granules. The colored cells or corpuscles, instead of being red, are, when examined by transmitted light, of a slight orange-green tint if seen single, and only approach a reddish tinge when cell is imposed upon cell several layers deep.

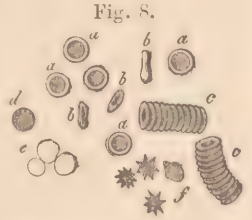
Form of colored corpuscles.—The general form of the colored corpuscle has been found to vary greatly in different orders of animals. In nearly all mammals the outline has been found circular, whilst in nearly all of the lower vertebrates it has been seen to be more or less elliptical. There are a few fishes (the lamprey eel and allied forms), however, in which round colored corpuscles have been met with; while, on the other hand, two species of mammalian animals (the camel and the llama) possess red cells of oval outline. A more rigid dividing line between the mammalian and the lower vertebrate animals with respect to their colored blood-corpuscles is afforded in the presence or absence of a nucleus. In the lower vertebrates, whether the red cell be round or elliptical, there is a central nucleus present. In the adult healthy mammalian corpuscle, the nucleus is generally admitted to be absent. Nevertheless, in opposition to this latter statement, Bœtcher and a few others have sought to prove the existence of the remains of a nucleus in the red corpuscle of mammalians also (man, among others).

Varieties of colored corpuscles.—In the healthy blood of adult man, the red corpuscles present two general varieties of form and dimension—the *red blood-disk* or *corpuscle* proper and the *microphyte*. Much the more numerous of these is the *red blood-disk*.

The red blood-disk or corpuscle.—As the word indicates, instead of being a spherical body, the red blood-cell is flattened into the form of a thin disk. Its outline is naturally circular, and in fresh arterial blood the central area of the disk presents a concavity on each side. In other words, besides being circular, the disk is normally *bi-concave*. The edge of the disk instead of being sharp or acute is rounded. In consequence of its peculiar shape, this form of the colored corpuscle, when seen in surface by transmitted light and properly focussed, should be most intense in color in the peripheral ring corresponding to the thicker portion. The color appears still more

intense when the disk is seen in profile. The colored corpuscle consists of three principal parts: the stroma, the fluid contents, and the coloring matter. According to some late investigators, the body of the colored blood-corpuscle is composed of a fine felt-work of minute fibrillæ (*b*, Fig. 1) of an albuminoid material, holding in its meshes a soft semifluid substance. The latter holds more or less closely united with it the coloring matter of the corpuscle, a substance which has been named *hemoglobin*. The weight of authority seems to incline to the opinion that the corpuscle is membraneless. The red disk is naturally elastic, capable of assuming any form which a moderate pressure may require, and of returning again to its original shape when the pressure is removed. Many experienced and accurate observers declare that they have seen it manifest limited contractile power. But most writers assert that it is incapable of any other than passive movements, regarding it as a more or less inert body, the altered remains of a once complete cell.

Fig. 8.



Human Blood-globules.—*a*, seen from the surface; *b*, from the side; *c*, united in rouleaux; *d*, rendered spherical by water; *e*, decolorized by the same; *f*, blood-globules shrunk by evaporation. (*Gray.*)

The red disks of human blood, when the latter is freshly drawn and spread out upon a glass slide for microscopic examination, frequently show a marked tendency to apply themselves one against the other by their broad surfaces to form rows similar to rouleaux of coins—a phenomenon the cause of which is unknown.

Alterations of the red corpuscles.—The colored corpuscle of man may experience various alterations of form and composition, which are purely physical or chemical, in contradistinction to amœboid or vital movements.

Water causes them to swell, to lose their bi-convex discoid shape and become more or less spherical, and to discharge their coloring matter into the surrounding plasma—which latter is now uniformly stained, while the corpuscle is apparently structureless, colorless, and sharply outlined. Many solutions of salts of less density than that of the blood have much the same action upon the red corpuscles.

On the contrary, when the density of the blood-plasma or of the artificial serum in which the colored corpuscles are examined is increased either by slow evaporation or by other means, the surface of the corpuscles, which is notably smooth, becomes wrinkled; subsequently, little prickles or spines appear all over the surface of the elements; finally, the corpuscles become more or less globular in form and diminished in diameter, retaining the while their prickly appearance. They are then known as crenated corpuscles. A few of this kind of cells are met with in nearly every specimen of blood. The addition of water causes them to swell and their spines to disappear, but they retain the spherical form. Carbonic acid causes the bi-concave disks to swell. When acting upon the crenate corpuscles, it causes the spines to disappear and the corpuscles to partly resume their former concave appearance. The action of this gas is generally not sufficient to effect a return of the concave surface upon both sides, but the corpuscle is made to assume a saucer shape.

A strong electric current first causes the red disks to become crenate and spherical; afterwards the corpuscles swell and lose their color.

Bile causes the red globules at first to become pale; after that they suddenly disappear, leaving no trace.

Urea causes the red disks to become globular, but does not effect a decoloration. Upon the surface of the corpuscle there are formed little drops of matter apparently entirely similar to the body of the cell, which are united with each other and with the body of the corpuscle by fine filaments.

The addition of tannic acid in sufficient amount to a portion of blood causes the hemoglobin to separate more or less completely from the body of the corpuscle and to form globular projections upon the surface, of the characteristic color.

Rapid desiccation of a thin film of blood, spread out on a glass slide, very perfectly preserves the form and dimensions of colored corpuscles.

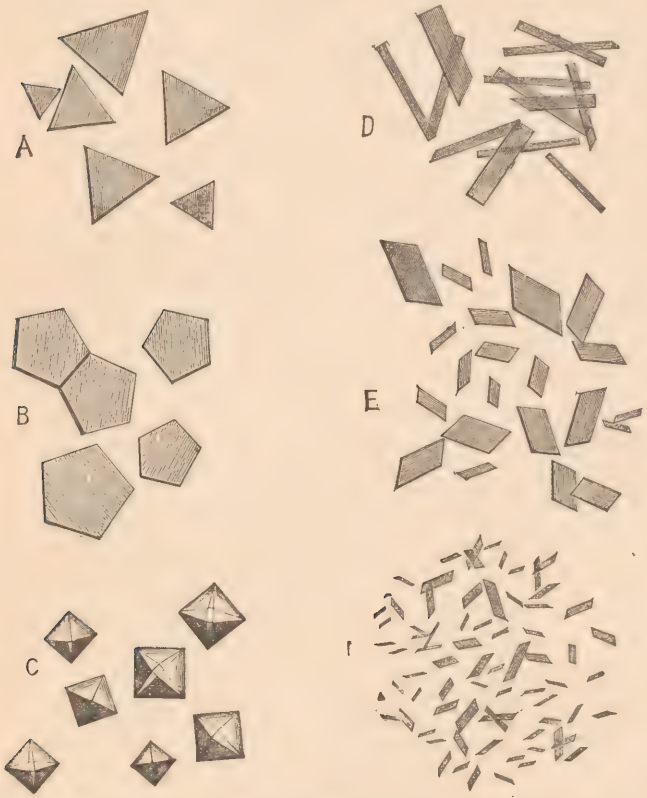
When blood is raised to a temperature near 134° F., the globules begin to lose their discoid form, and to assume a spherical shape. At the same time little buds make their appearance upon the surface of the corpuscle, united to it and to each other by fine filaments. When the temperature reaches 158° F. the globules become decolored and broken up into small transparent spheres of very unequal size.

Cold causes a dissolution of the hemoglobin, and an effect similar to that of water.

Blood-crystals.—When extravasated into the tissues, colored corpuscles disintegrate by breaking into minute portions, the coloring matter of which finally is transformed into brown pigment-granules, known as *hematin*. Besides these granules of pigment, such extravasations may contain crystalline needles of a reddish-brown color—*hematoidin*-crystals. But the characteristic crystals of the blood are those of *hema-*

globin, usually deposited from a considerable quantity of blood. The form of the hemaglobin-crystals varies in different animals, and is often quite peculiar to certain species. These characteristic forms often

Fig. 9.



Blood-crystals.—A, trihedral crystals from blood of Guinea-pig. B, pentagonal crystals from blood of Squirrel. C, octahedral crystals from blood of Rat and Mouse. D, hematin-crystals from Human blood. E, hematoidin-crystals from an old apoplectic clot. F, hemin-crystals from blood treated with acetic acid. (*Gray.*)

yield valuable suggestions as to the kind of animal from whence they came.

Crystalline forms, artificially derived from hemoglobin, and valuable in medico-legal examinations of supposed blood-stains, are those obtained from dry blood by the action of glacial acetic acid. They consist of nut-brown, rhombic, crystalline plates, called *hemin*-crystals, or hydrochlorate of hematin.

Fig. 10.



Hemin-Crystals, by Teichmann, in hydrochlorate of hematin.

The red blood-disk of man varies somewhat in dimensions. Its mean diameter, as is seen by reference to the table on a previous page, is about $\frac{1}{3200}$ of an inch. This size may vary somewhat among different individuals, and in the same person at different times.

The microphyte.—In every specimen of human blood there are among the red bi-concave disks, already described, a small number of colored globular corpuscles of much less diameter, and of a darker tint. Their size may be not greater than $\frac{1}{5000}$ or $\frac{1}{6000}$ of an inch. They appear to possess the same intimate structure, and to give the same chemical reactions as do the red bi-concave disks. They have been called *microcytes*. By some histologists they are regarded as young, not yet fully developed, red blood-corpuscles (*hematoblasts* of Hayem), since they seem to be more numerous at times when the blood is undergoing repair. By others they are thought to be the old bi-concave disks undergoing retrograde changes. They are especially abundant in progressive pernicious anæmia.

The white or colorless corpuscles. — Of the *colorless corpuscles* of human blood, cells similar to those of the three general classes of colorless cells described as present in the lymph are found, and it is not necessary here to review their characteristics. Their number, however, is usually far below that of the colored elements. It varies much even in health, and in the same individual, from one time to another. In comparing the white corpuscles with the red, Welcker has the average as 1 white to 335 red, Moleschott 1 white to 357 red, Klein has placed the highest number in health at 1 white to 650 red. We have the authority of Moleschott for the statement that boys have 1 colorless to 226 colored corpuscles, old men 1 to 381, girls 1 to 389, young women menstruating 1 to 247, the same women when not menstruating 1 to 405, pregnant women 1 to 281. According to Hirt the proportion of white corpuscles to the red is low immediately after eating, while two or three hours later, the proportion is again near the normal. The same author states that the proportion in the blood of the splenic vein is 1–60; in the splenic artery 1–2260; in the hepatic veins 1–170; in the portal vein 1–740. It would seem from these figures that there may be at times a physiological leucocytosis, although this has been denied by some later investigators. Groucher declares that the proportion of the white to the red corpuscles varies little in the course of the day. In disease the relative number of the white corpuscles has even surpassed the proportion of 1 white to 3 red cells.

Red granular corpuscles. — Besides the ordinary white corpuscles, Semmer has observed in the blood of mammals certain numbers of more or less granular, nucleated, colorless cells, of somewhat larger size than those above considered, which contain red granules of considerable size, and has named them *red granular corpuscles*. According to this author, as well as A. Schmidt, they are probably intermediary

forms between the white cell and the red corpuscle of the blood.

Ovoid colorless cells.—Von Recklinghausen has met with a few colorless, ovoid, granular, nucleated cells in the blood of frogs. In these animals they seem to be more numerous in certain seasons of the year, being much more frequent in the spring and summer.

Many accurate observers have seen similar colorless elements in the blood of man. They have been met with chiefly in the blood of patients suffering with certain febrile disorders. In the blood of relapsing fever subjects they are not infrequent; they have also sometimes been encountered in typhoid fever. In the two latter cases these cells are often loaded with fine fatty granules. The writer has met with such cells, in some abundance, in inflammations affecting the bloodvessels, and believes with Semmer that they may be regarded as normal to the blood of certain, if not all, mammals. During the same study of inflammation of bloodvessels we had the opportunity once or twice to observe under the microscope endothelial cells, lining the vessels, become detached and carried off in the blood-current. These observations leave us no doubt that at least some of the ovoid, colorless cells, above mentioned, are to be assigned to a similar origin, namely, a limited desquamation of the endothelia lining the vessel walls.

Free granules.—The plasma of the blood also carries in suspension numbers of minute particles apparently identical with the *free granules* described as present in the lymph; their number as well as their nature varies in much the same manner. Of course, in the blood some of these minute particles arise from a destruction by disintegration and fragmentation of the superannuated red blood-disks.

Regeneration.—In the blood, as in the other tissues of the organism, the various stages of generation, development, vigorous activity, decay, and disintegration are constantly presented by the different elements. After hemorrhage, whether natural or accidental, it would seem that the investigator has offered to him very ample opportunity of studying the methods of regeneration by which immense losses of the red blood-globules are rapidly repaired. To replace the ordinary periodic destruction of red blood-disks which women suffer at the time of their catamenia, about one hundred and seventy-five million of red corpuscles, it has been calculated, must be produced every minute during the intermenstrual period. Yet, the question of the renewed supply of colored elements of the blood, notwithstanding the many exhaustive investigations of hematologists, has not up to the present moment been satisfactorily answered. It seems to be generally admitted, however, that in some way the red disks are elaborated from the colorless cells, either of the blood or of the lymph, but the diversity of opinion as to the precise method of formation during adult life, is great among some leading modern histologists.

Movements of the corpuscles.—Heat and the other reagents which were mentioned when considering the elements of the lymph, have identical effects upon the colorless cells of the blood. Wherever the circulation of the blood is sluggish, and heat and oxygen are present in sufficient quantities, large numbers of the white corpuscles put forth active movements. These movements are much more energetic in the small venules than in any other portion of the circulatory system. It is here and in the capillary vessels that the viscosity or stickiness of the colored elements especially shows itself, and it is mainly here also that the amœboid corpuscles stick to the walls of the vessels and ultimately pass through them. The fact that they do traverse the walls of these vessels is not now questioned; but writers are not yet agreed as to the manner in which the act is accomplished, some believing that it is effected by the active creeping of the corpuscles through minute pores, which ordinarily are filled with a soft permeable substance, others claiming that the extravasation of the corpuscle is passive, entirely effected by the outward pressure of the blood against the walls of the vessel; still other opinions have been advanced. It is admitted, however, that the more active the amœboid movements from any cause, the more rapid and extensive is the emigration. It has long been known that the red elements also escape through the vessel walls. The diapedesis of these elements, however, is generally believed to be in the main passive; perhaps it takes place through passage-ways already opened by the previous emigration of a white amœboid cell. In these emigrations of the elements of the blood through the walls of the vessels, the cells are often fragmented, and the fragments are according to circumstances carried off by the lymph current without the vessel or by the blood current within it.

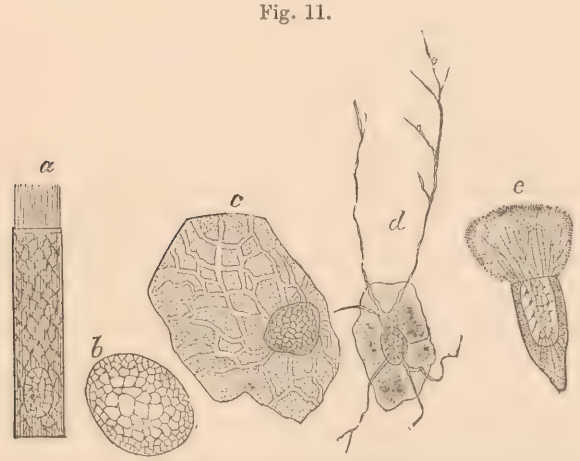
Like the lymphatic fluid, the *plasma* of the blood contains a certain proportion of fibrin which sooner or later deposits itself when the blood is left to stand. The nature and structure of the fibrin of the blood are very similar to those of the fibrin of the lymph. It is supposed to be the result of the action of a so-called fibrinogenous upon a fibrinoplastic substance contained in the plasma.

Derivation of blood and lymph.—All the foregoing elements in the lymph and in the blood are to be regarded as derivatives immediately or indirectly of the connective-tissues of the organism—descendants from the middle or connective-tissue layer of the blastoderm, or mesoblast.

ENDOTHELIUM.

We now pass to the consideration, in the endothelia, of another variety of the connective-tissue elements which are widely distributed. They are flat cells, which usually in a single layer are found lining the surface of serous cavities, the inner surface of blood- and lymph-vessels, and the synovial membranes. They consist of a more or less flat cell-plate, of an albuminous somewhat elastic substance, and one or more nuclei possessing a double-contoured membrane, a more or less oval outline, and an excentric location in the body of the cell. The cell-plate consists of an elastic network of fibrils (the intra-cellular reticulum) inclosing in its meshes a semifluid homogeneous colorless substance. The nucleus also consists of a similar but denser network (the intra-nuclear), holding in its spaces a similar semifluid substance (see *c*, Fig. 11).

Fig. 11.



Cells showing the Reticulum in the Protoplasm and Nucleus.—*a*. Columnar epithelial cell provided with cilia, the latter being prolongations of the intra-cellular network. *b*. Nucleus of a glandular epithelial cell from the stomach of a Newt, showing the intra-nuclear network. *c*. Endothelial cell of the mesentery of a Newt, containing in a hyaline ground-substance a plexus of fine fibre-bundles—intra-cellular network—in connection with the intra-nuclear network. *d*. Connective-tissue corpuscle from mesentery of Newt, showing very clearly the intra-cellular network of fibrils and the hyaline ground-substance; the former extends into the branched processes, and is also connected with the more delicate intra-nuclear reticulum. *e*. Goblet-cell from the stomach of a Newt, showing the intra-cellular network in connection with fibrils of the intra-nuclear network; the upper part of the cell is greatly swollen by mucus. (*Klein.*)

The cell appears to be without a membrane. The nucleus is much flattened when the cell-plate is thin, and causes a prominence corresponding with its location. Normally the cell-plate is so thin and transparent that its outlines are indistinguishable, the nucleus alone being visible. Neighboring cells are placed nearly in contact by their edges, being separated only by a very small amount of structureless transparent viscid substance which holds them together. This material has been called *cement-substance* (*intercellular cement*). When these cells are seen in profile they appear to be more or less linear or spindle-form, the thickness of the spindle corresponding to the nucleus of the cell. After staining with a weak solution of nitrate of silver, the intercellular cement is so darkened that the outline of the cell is made very distinct. It is thus found that endothelial cells have more or less irregular polygonal outlines (consult Fig. 12), and that the

Fig. 12.



Normal Endothelium of Visceral Pericardium of a Toad, silver-treated and highly magnified. (*Chapman.*)

extent of the cell-plate is extremely variable. In the arteries and larger lymph-vessels the cells are more or less lozenge shape, with the border lines only slightly wavy. In the veins and lymph-capillaries, the cells are much broader as a rule, and their periphery is represented by extremely irregular indented lines (consult figs. 1, 3, Plate XII.). Upon the surface of the serous cavities the outlines of the elastic cell-plates present still another picture, as will be seen by reference to fig. 1, Plate I. Besides variations in the outlines of endothelial cells, there are other differences which are shown mainly upon serous surfaces In the adult animal the greater part of these surfaces is covered by a single layer of extremely thin, nearly hyaline, and somewhat broad cell-plates. There are, however, limited areas more or less numerous scattered here and there upon which the cells offer a very different aspect. They are much narrower, their edges are much less irregular, they are much thicker when seen in profile (approaching a cubical form), are quite granular, and possess two or more nuclei. In fact, they appear to be in a decidedly active state, while, on

the other hand, the vital proclivities of the first mentioned very thin hyaline cell-plates seem to be entirely dormant. These granular cells are said by Klein and some others to be germinating, and have been called by them *germinating endothelia* (see *e*, fig. 1, Plate I.). They are generally arranged around the mouth of a vertical canal connecting a lymph-channel of the sub jacent connective-tissue with the serous cavity. The activity of this germinating endothelium may be such that the granular cells proliferate and form new cells, some of which may be set free in the serous cavity. These new cells are similar in every respect to the other lymph-corpuscles which float in the lymph-plasma, and cannot, after separation from their place of generation, be distinguished from them. The endothelia covering some portions of the abdominal cavities and the fenestrated septa of the mediastinum are thus a very fruitful source of supply of the colorless corpuscles of the lymph.

The endothelia are, as already stated, somewhat elastic. When the membrane which they cover is stretched, they become thinner, and spread out in order to cover a wider extent of surface, and their border becomes straighter. On the contrary, when the membrane retracts, their broad diameter lessens, their borders become more sinuous, and the cell be comes thicker. Thus during full inspiration the endothelia covering the pleural surface of the lungs are much thinner and broader than at the end of expiration. At the latter instant the pulmonary endothelia are quite cubical in shape.

As has already been indicated, the endothelia not only of the serous cavities, and of the lymph-vessels, but also of the bloodvessels as well, may be regarded as some of the sources of the colorless elements to the lymph and blood.

CONNECTIVE-TISSUE CELLS.

Still another group of the elements derived from the mesoblast is formed by the cells of the connective-tissue. They may be considered under two general heads—the wandering cells and the fixed cells.

Wandering cells.—The *wandering cells* of the connective-tissue are not different from the colorless cells already described when considering the lymph. They are in reality lymph-corpuscles, existing in the radicles of the lymphatic system, and do not call for any particular description here. One form may be considered for a moment, however, before dismissing them. There are found in the interstices of the loose connective-tissues which are especially vascular, small numbers of large granular corpuscles slightly pigmented (plasmatic corpuscles of Waldeyer). They are more frequent along the walls of vessels, and do not usually exhibit marked amœboid movements.

Connective-tissue corpuscles.—The *fixed cells* of the connective-tissue vary much in shape according to the arrangement of the fibrous tissue in which they are imbedded.

The cellular elements of the great connective-tissue system are met with only within or upon the sides of the spaces which permeate that system, whether they be in the form of fine channels or in the nature of lymph-cavities, and whether those spaces be large or small. The large spaces, as, for example, the peritoneal cavity, the pleural cavity, the arachnoid cavity, the heart and bloodvessels, the larger lymph-vessels, are lined throughout by a complete covering of endothelial cells; the minute spaces which exist between the bundles of connective-tissue fibrils have as a rule only a more or less incomplete lining. But whether the space be of one kind or of the other, it is lined by cells of an essentially identical nature; only their forms and the arrangement of some of their structures, vary according to the circumstances which surround them. Although the fixed cells of the connective-tissue are here considered under a special section different from that in which the endothelia were discussed, it is not because these two species of cells differ in anything more than form.

The so-called fixed cell of the connective tissue tends to assume a form which is a more or less perfect mould of the space in which it is found. It presents two general forms, the one plate-like, the other stellate. The plate-like forms more nearly resemble the cell-plates of the endothelia than do the stellate forms, and will therefore be considered first (see *c*, fig. 3, Pl. IX.).

Flat tendon-cells.—In white fibrous tissue such as tendon, etc., the spaces formed by the apposition of several bundles are linear, and are limited laterally by the convex surfaces of the fibrous bundles. The surface of the space thus formed is usually partially lined only. On one side is a longitudinal row of flat elastic cell-plates, applied more or less tightly to the surface of the fibrous bundles forming that side. The opposite side of this minute lymph-space is void of cellular lining. The cells constituting this row are placed edge to edge, and at the line of junction the border of the cell is quite straight, and generally transverse to the direction of the bundle. These cells thus have two long straight parallel sides. The lateral borders of the cell are more or less notched,

and sometimes processes of considerable length, and more or less branched, spring from them. A single cell will generally spread across two or more bundles. When this is the case, the indentation of the space caused by the convex surface of two bundles coming together, is filled out by the substance of the cell-plate. In consequence of this circumstance, when the cell-plate is detached from its position and examined at once, a ridge extends from one parallel side of the cell to the other (see *e*, *B*, fig. 2, Plate III.). This ridge appears like a band running in the body of the cell when the latter is viewed in surface. Sometimes it may be developed into a secondary cell-plate of some width, springing from the first, thus complicating the form of the cell. These cells are known as the *flat tendon-cells* of Ranvier. They may very justly be regarded as a special form of endothelium. The cell-plate is elastic, and contains an ovoid nucleus near one straight side. It consists of an intercellular network which corresponds with the extent of the elastic plate, and at the notched sides extends beyond the plate into the processes; and the nucleus contains an internuclear reticulum. Seen edgewise, these flat tendon-cells appear spindle-form, and when seen in optical or real transverse section they present a more or less branched or stellate aspect.

Stellate cells.—In loose connective tissue, or areolar tissue, where the bundles of fibrils intercross in every conceivable direction, the most irregularly formed minute lymph-spaces are found. These spaces are more or less stellate, and they often contain one or more fixed stellate cells. These are the *connective-tissue corpuscles*, par excellence. They lie in the small lymph-cavity, loosely attached to one of the sides of the space. The simplest form of this cell in adult tissue is that of a thin cell-plate of more or less irregular outline, and containing an ovoid nucleus. The nucleus has an enveloping membrane of double contour, and contains an intra-nuclear, very dense network, the nucleus seeming to be implanted nearer to

EXPLANATION OF PLATE I.

Fig. 1. Peritoneal surface of the centrum tendineum of a Rabbit, silver-stained and highly magnified. (After Klein.)

b, Smaller endothelial plates, situated over the straight lymphatic vessels which lie between (*a*) the tendon-bundles; *e*, true stomata, some widely open, some collapsed,—they form a means of communication between the serous cavity of the peritoneum and those straight lymphatics last mentioned, and are lined with endothelial cells of a germinating character; the dotted line starting from *c* represents the outline of a lymph-sinus below the surface, and in communication with the before-mentioned straight lymph-vessels.

Fig. 2. Highly magnified view of the spine-covered epithelial cells of the rete mucosum, or deep layer of the cutaneous epithelium. The section is parallel with the surface, and includes some underlying connective-tissue. (After Ranvier.)

a, Bloodvessels with surrounding lymph-spaces; *f*, connective-tissue bundles cut transversely; *b*, union of the epithelium with the tissue of the cutis; *e*, polyhedral epithelial cells of the rete mucosum, containing oval nuclei and minute brilliant nucleoli. These cells are united together by means of their spines, *c*; an intercellular cement fills the interspaces formed by the spines.

Fig. 3. Various forms of epithelium, fresh and much magnified. (After Ranvier.)

a, Thin, broad, epithelial scale from the inside of the cheek, showing a very small nucleus, and finely-granular contents,—the imprint of adjoining cells is observable in the innermost line; *b*, smaller epithelia, from the deeper epithelial layers of the bladder, and *c*, a larger epithelial cell from a more superficial layer; *d*, an isolated spinous epithelial cell from the rete mucosum of the skin; *n*, the nucleus of a ciliated columnar epithelial cell, whose vibratile cilia are shown at *g*; *k*, the elastic striated plate from which project the cilia of a smaller ciliated columnar epithelium; *p*, *q*, the deep extremities of columnar cells.

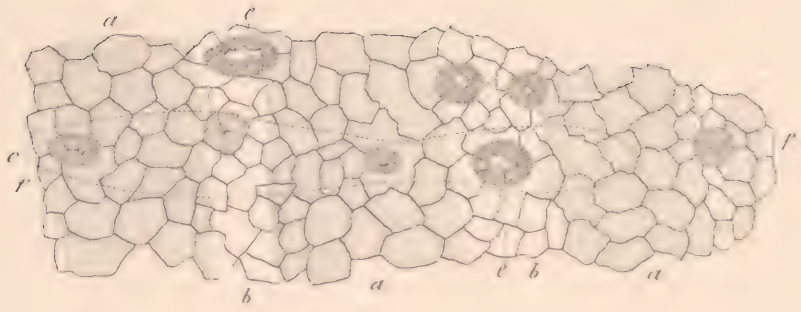
Fig. 4. Three isolated columnar epithelia from the intestine.

h, The striated elastic plate which limits their free extremity; *n*, the oval, double-contoured nucleus of the cell.

Fig. 5. *A*. Profile view of epithelia of the bronchus of a Rabbit, showing, between the regular ciliated columnar epithelium, *d*, the existence of *branched cells*, *e*, of a different nature, whose processes form a more or less complete network with each other, as well as a communication with the branched connective-tissue corpuscles, *a*.

B. A surface view of the same epithelia, the letters having a similar indication.

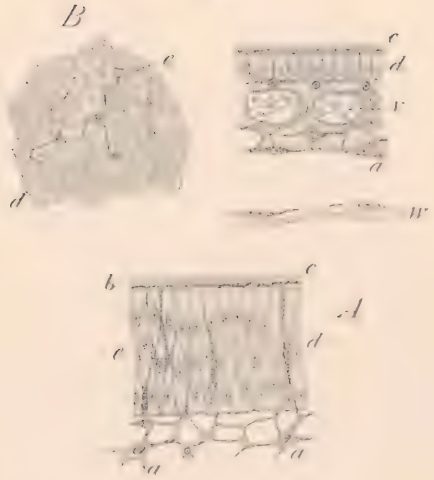
C. Shows a longitudinal section of a minute bronchus. *d*, Columnar epithelia, of which, *c* are the cilia; *v* is the muscular coat, the smooth muscle-fibres being cut transversely; *a* is a lymph-vessel of the adventitious coat of the bronchus. (After Klein.)











T. Sinclair & Son, lith.

one surface of the cell than to the other. This intra-nuclear network is in connection with an intra-cellular network, which is in part imbedded in the elastic cell-plate, but it at some points extends beyond the edge of this plate to form more or less branched processes (see *d*, Fig. 11), which attach themselves to the adjacent fibrous bundles, or to the processes of other branches or of other cells. Instead of presenting this simple form, secondary cell-plates may spring from the primary body and send off processes, when the connective-tissue corpuscle becomes a very complex affair. Yet it essentially consists of a thin elastic plate similar to that of the flat tendon-cell already described, and can be classed in the same category.

These fixed cells of the connective-tissues are believed by some accomplished histologists to be capable of limited vital movements during health. It is undeniable that under the influence of irritation they can, and often do, return to an active state, when they may put forth all the powers of the amœboid lymph-corpuscle.

EPITHELIUM.

With this subject we come to the study of a class of elements possessing an ancestry and functions totally different from those of the minute forms previously considered.

The cutaneous epithelia are the representatives of the epiblast, or the upper layer of the blastoderm. On the other hand, the epithelial cells of the intestinal canal spring from the lower layer, or the hypoblast of the blastoderm of the embryo.

THE EPITHELIUM OF THE SKIN.

Spinous cells.—The cellular elements covering the skin afford several varieties of investing epithelium. In the rete mucosum the epithelial cell is soft, apparently granular, membraneless, and polyhedral from mutual pressure. It is constituted by a cell-body, and generally only one spherical vesicular nucleus. The cell-body consists of a network of fibrils holding in its meshes a semifluid, hyaline substance. The nucleus also is formed of a network, and an interfibrillar substance, and is limited by a double-contoured membrane. There are also in the nucleus often one or more small granules (nucleoli), the remains of a hyaline, albuminoid material, from which the nucleus was originally developed. The periphery of these soft membraneless cells of the rete mucosum is furnished with small prickles or spines (see *c*, fig. 2, Plate I.), which are frequently wanting on the periphery of neighboring cells. These *spinous cells* have been called by various names, such as the dentate-cell, the prickle-cell, and the riff-cell. Adjacent cells are effectually held together by the union of their spines, and by a viscid cement substance (intercellular cement) similar to that above mentioned for the endothelium.

During irritation this cement substance increases in amount but lessens in viscidity. The lines of separation between the cells then become quite distinct. Fig. 2, Plate I., presents a very truthful picture of the relations which these cells bear to each other.

The deepest of the rete-cells, namely those in contact with the fibrous tissue of the cutis, are more or less *columnar*, or rather conical in form. The large ends abut against the polyhedral rete-cells previously mentioned, while the small ends fit accurately into indentations of the papillary layer of the derm. In the dark-skinned races, these columnar cells are more or less pigmented.

Stratum granulosum, and stratum lucidum.—The outermost layer of the rete-cells is covered with a thin lamina of flattened, intensely granular cells, forming a layer about two cells deep, the *granular layer* of Langerhans (see Fig. 13). Immediately external to the thin granular layer is a second, which has received the name of the *stratum lucidum* of Schrön. This layer is of slight thickness, the cells are transparent and hyaline, and occasionally exhibit nuclei.

Corneous layer.—Placed upon the stratum lucidum are the most superficial cells of the cutaneous epithelium. They are all converted into dense, *corneous plates*, with no trace of their reticular or nuclear structure remaining. They form a layer of variable thickness in different locations—the *stratum corneum*, or corneous layer.

The outermost cells of the rete mucosum, or rete Malpighii, have lost their regularly polyhedral form, and have become somewhat flattened, so that in a vertical section of the skin they are seen in profile, and appear more or less spindle-shaped. The cells of the granular layer are still more flat. Those of the stratum lucidum have been flattened into mere scales, which, seen in profile, look like interrupted lines. In the cutaneous epithelium we have, therefore, five varieties of epithelial cells, named from below upwards as follows: the columnar, granular, spinous, lucida, and corneus. Among the soft, membraneless, polyhedral cells of the rete mucosum are, according to some late investigators, a few spindle-form, or stellate nucleated cells, whose branching processes run in the intercellular cement-substance, and

Fig. 13.



Vertical Section of the Human Skin.—*a*. Corneous layer of epithelium. *st. l.* Stratum lucidum. *gr.* Stratum granulosum. *b*. Rete mucosum and papillary layer of cylindrical cells. *c*. Papillæ of skin. *d*. Tactile corpuscle. *e*. Sebaceous gland. *f*. Hair-bulb. *g*. Erector pili muscle. *h*. Convolution of sweat-gland. *i*. Pacinian corpuscle. *j*. Panniculus adiposus (fat-layer). *k*. Vascular loop. Low power. Partly diagrammatic. (*Duhring.*)

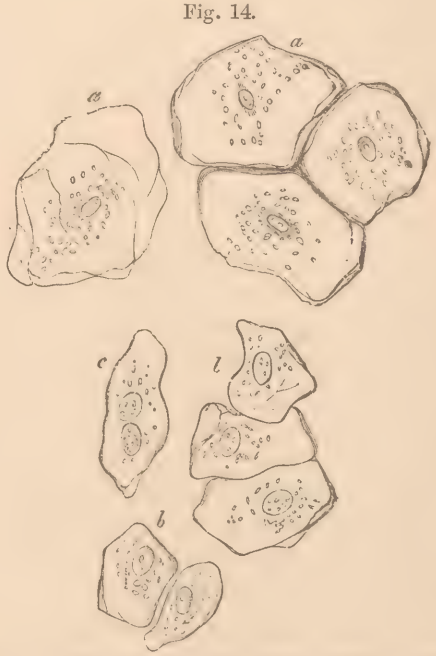
often unite with the processes from neighboring cells of a similar nature (see *e*, fig. 5, Plate I.). They are thought by some to possess the characteristics of connective-tissue corpuscles; others believe them to be only amœboid lymph-corpuscles; while still others believe them to be peripheral nerve-corpuscles in communication, by their deep processes, with fine filaments of the superficial cutaneous nerves.

The covering of the skin, being composed of numerous layers of cells superimposed upon each other, mainly of a flattened scaly form, is termed a *stratified squamous* epithelium.

THE EPITHELIUM OF MUCOUS MEMBRANES.

Squamous epithelium.—In the mouth of man, the epithelial covering of the mucous membrane is nearly identical with that which covers and protects the skin. The stratum granulosum and the stratum lucidum, however, are absent. Moreover, because of the constant moist condition of the epithelial layers upon this mucous membrane, the corneous layer of cells is comparatively thin, and is composed of thin scales in which small nuclei may be seen. The deep layer of columnar cells is but little pigmented. Some later histologists note, throughout mucous membranes and the small accessory glands attached thereto, the existence of a single layer of flat endothelial cells, between the epithelium and the connective-tissue upon which it rests.

Fig. 14.



Epithelial Cells in the Oral Cavity of Man: *a*, large; *b*, middle-sized; *c*, the same with two nuclei. High power. (*Gray.*)

The cellular covering of the mucous membrane of the oral cavity is, therefore, to be regarded as a *stratified pavement of squamous epithelium*. This is the character and arrangement of the epithelium of the lower part of the pharynx, of the œsophagus, the edges of the epiglottis and of the true vocal cords, of the anus, of the intra-vaginal portion of the cervix uteri, of the vagina and vulva, of the glans penis and prepuce, and of the anterior third of the nasal cavity.

The pulmonary alveoli are lined by a single, sometimes interrupted layer of squamous epithelium, having a histogenetic origin similar to that of the epithelium of the bronchi.

In the olfactory region of the nasal cavities, in the upper portion of the pharynx, in the larynx, trachea, and bronchi, the cellular investment consists of a *stratified columnar ciliated epithelium*. In the Fallopian tubes and in the fundus uteri and extra-vaginal portion of the cervix uteri, the mucous membrane is covered by a single layer of ciliated columnar epithelium. The internal surface of the stomach and intestines is lined by a *simple columnar epithelium*.

Simple columnar epithelium.—The *columnar epithelial cell*, when it presents one of its ends upon a free surface, usually is limited at that end by a thin plate of considerable stiffness, which seen edge-wise, as when the cell is viewed in profile, appears like a brilliant band. In the simple columnar cells of the intestinal canal, under favorable conditions, this brilliant band seems to be vertically striated (see Fig. 15). By violence the thin limiting plate is often partially or completely detached from the end of the cell. Frequently the cell possesses a very delicate limiting membrane, which, however, is probably only a condensed film of the body of the cell. The columnar cell is somewhat soft and pliable, and may, therefore, readily assume shapes imposed upon it by pressure. It is rarely absolutely columnar; it is frequently more nearly conical. Often its deep end divides into two or more short thick branches (see *p*, fig. 3, Plate I.). It is provided with a nucleus which is oval or more or less rod-shaped possesses a thin membrane of double contour, and generally one or more distinct nucleoli. The nucleus is usually located near the deep extremity of the cell. The body of the cell is composed of a network of fibrils, whose meshes have a decided linear shape, mainly parallel with a long axis of the cell. The nucleus also contains a network which, like the nuclei of other cells, is denser than that of the cell-body. The finely granular appearance of the cells is due to the existence of this reticulum. The semifluid material contained in the meshes of the reticulum may vary in amount, and cause the interfibrillar spaces to increase more or less in extent, thus increasing or lessening thereby the granular aspect of the whole or a part of the cell.

Fig. 15



Section of a Villus of a Rabbit, furnishing examples of non-ciliated columnar epithelium. High power. (*Stricker.*)

Ciliated columnar epithelium.—The *ciliated columnar epithelium* is essentially similar in structure to the simple columnar cell. It differs from the latter only by the presence of a number of fine cilia or hairs vertically attached to the thin plate at the free extremity of the cell (see *g*, fig. 3, Plate I.). These cilia pass through the thin limiting plate and are directly attached to the fibres of the intra-cellular reticulum (see *a*, Fig. 11). During the life and the activity of the cell the cilia are in more or less vigorous vibratile motion, and those agents which excite or retard movements in the amœboid corpuscles have the same action upon the movements of the cilia.

In stratified ciliated columnar epithelial coverings, the ciliated columnar cells constitute the superficial layer. They are usually present in a single row. Between and below the deep extremities of these ciliated cells are a greater or lesser number of spindle-form and more or less irregular polyhedral epithelial cells. These are usually membraneless, and contain one or more spherical nuclei, the minute structure of the cell being reticular. Scattered here and there among the columnar and other cells are a few soft granular membraneless bodies, sometimes fusiform, sometimes branched, apparently similar to the analogous cells mentioned under the cutaneous epithelium (see *e*, fig. 5, Plate I.).

Goblet-cells.—Some of the columnar cells, whether ciliated or not, may become distended and distorted with a collection of mucus near the free end. Such cells are known as *goblet-cells* (see *e*, Fig. 11). The nucleus is generally pressed aside and crowded into the deep end of the cell. If the accumulation of the mucus continue, the thin limiting plate is broken or detached, an occurrence which results in the discharge of mucous drops upon the free surface of the

epithelium, and the probable ultimate destruction and desquamation of the cell. During the progress of gastric digestion, these goblet-shaped columnar cells are to be found in great numbers upon the mucous coat of the stomach.

The epithelial cells of the mucous membranes, like those of the skin, are slightly separated, yet closely and firmly held together by an intercellular cement. According to the investigations of some authors (Klein among others), foreign particles placed upon the surfaces of mucous membranes are absorbed mainly, if not exclusively, by means of the intercellular cement-substance, which, at the surface of the fibrous tissue, is in direct communication with the superficial lymph-spaces of the connective-tissue. Even in the intestines the minute particles of the chyle, according to Klein, are not taken up by the columnar cells, and thence passed into the radicles of the lacteals, but they enter the intercellular cement, which reaches the free surface, and pass along this until they reach the lacteal capillaries.

GLANDULAR EPITHELIUM.

Under this caption we consider cells of widely-varying function and location. As a rule, they have an embryonal derivation similar to that of the investing epithelium, upon which the ducts of their glands empty. In fact, they commonly begin to develop at an early period of intra-uterine life by epithelial buds, which project from the deepest layers of this investing epithelium into the subepithelial connective-tissue.

Glands of mucous membranes.—The epithelial glands, which open upon the surface of mucous membranes, seem to be constructed upon two general plans, if we are to judge from the nature of their lining epithelium. The various forms of these glands seem to be only modifications of two models.

1. *Simple tubular mucous glands.*—The simplest kind of epithelial gland is, perhaps, the crypt or follicle of Lieberkühn. It usually presents the form of a small tube, closed at the deep extremity by a cæcal end, and opening at the other upon the surface of the intestinal canal. The cells, lining the tube in a single layer, are apparently identical in structure and form to the columnar epithelium of the surface. They are short, cubical, or columnar cells, which possess a spherical or oval nucleus, with a thin, double-contoured limiting membrane. The gland-tube is usually single, but sometimes may be branched in its deep extremity. The deeper portion of the gland is frequently slightly larger in diameter than is the upper portion or neck of the gland. In the wider portion the cells are longer. The columnar cells consist of a network, which is denser in the nucleus than in the cell-body. The fibres of the reticulum have a general direction parallel with the long axis of the columnar cell, namely, perpendicular to the wall of the tube. They are separated from the latter by a thin, flat, sometimes branched, endothelial cell, and separated from their neighbor-cells by a small amount of cement-substance, into which sometimes branches of the endothelial cells above mentioned may project. The free end of the columnar cell may contain a drop of mucus, when it constitutes what has already been described as the goblet-cell. The chief, if not, indeed, the only function of these cells is the secretion of mucus, and the gland itself may be regarded as the simplest form of a mucous gland. The cells in the quiescent state are smaller, and apparently more granular than when the cell is actively forming and excreting mucus. At no time, however, during health, is the cell coarsely or densely granular. It is to be remarked also that the longitudinal striation of the cell—an appearance in itself due to the prevalent longitudinal direction of the meshes of the intra-cellular and intra-nuclear reticula—is somewhat more marked in the neck, and at the orifice of the gland, than in its fundus. Besides the foregoing characteristics, these purely mucous tubular glands possess a distinct lumen throughout their length.

2. *Compound tubular mucous glands.*—In the mucous glands of the mouth we have an example of a compound tubular gland, whose chief function is the excretion of mucus. Here we have not only a modification of the form of the simple tubular gland, but there is also a complication of the lining of the tubes. Some of the largest of these glands may be taken as a type for description. Each gland consists of a large duct, funnel-shaped at its mouth. The duct passes more or less obliquely through the mucosa. Reaching the submucous tissue it divides into a number of smaller tubular branches, each of which soon slightly enlarges to form an infundibulum. Very soon the infundibulum again narrows, and passes into the secreting portion of the tube, which, after turning irregularly in numerous convolutions, ends in a cæcal extremity. In man, the funnel-shaped mouth of the duct has a lining of stratified pavement epithelium. At a slight depth, however, the epithelial lining of the duct is seen to consist of a single layer of long, narrow columnar cells, with intra-cellular and intra-nuclear

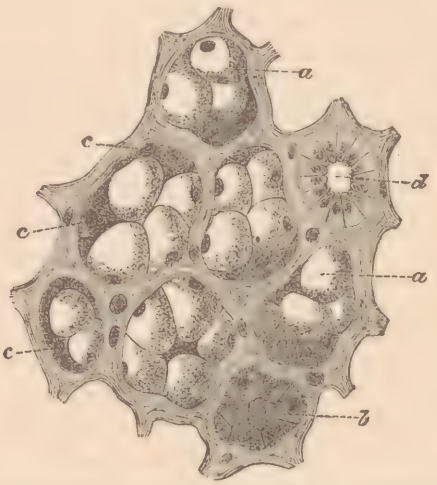
networks, producing a distinct longitudinal striation, and a slightly granular appearance of the cell. The lumen of the duct has considerable width. In the narrow tubes, into which the duct branches, the epithelium is still in a single layer only, but the cells are now much shorter and wider. They may be cubical, or even more flattened. The cells still contain networks, but these are neither dense nor arranged so as to produce an apparent striation.

In the infundibulum the lining epithelium still preserves this more or less flattened form. The lumen of the infundibulum is consequently comparatively wide. As the deep portion of the infundibulum is reached it again slightly narrows to pass into the convoluted tubes. At the same time the character of the lining epithelium again changes. Their cells now become columnar and very slightly granular. They contain a round or oval double-contoured nucleus, which is located near the outer end of the cell, both cell-body and nucleus consisting of a network of fibrils forming comparatively large meshes when the gland is fully developed. When the latter is active, these cells contain drops of mucin in their inner portion, and present every characteristic of goblet-cells. When exhausted, they shorten very considerably and become very granular, and consequently somewhat opaque. The lumen of the convoluted tube is characteristically large. The epithelia of these glands rest upon a layer of endothelial or connective-tissue cells which are more or less branched, some of the branches penetrating as septa between the intercellular cement which holds the cells together.

Sometimes in the convoluted portion of the glands two, three, or more embryonal cells are found at rare intervals along the course of the tube massed together in thin clumps, and they are always located between the previously described columnar epithelium and the layer of endothelial cells which form the basement-membrane of the tubes.

The sublingual gland of man and the submaxillary gland of the dog are mucous glands still larger than those last considered, but they are constructed upon the same general plan with, however, an epithelial lining a little more complicated. In the convoluted portion of the tubes, protoplasmic collections between the mucus-cells and the basement-membrane of stellate endothelia, somewhat similar to the embryonal cells mentioned as occasionally present in the last-described mucous glands of the mouth, are in these glands very numerous. These protoplasmic masses are more or less crescentic, and have received the name of the *crescents of Gianuzzi*, after the anatomist who first accurately described them. They are densely granular uni- or poly-nucleated masses without a defined membrane, but with projections which fit into the spaces between the epithelial cells with which

Fig. 16.



Submaxillary Gland of Dog.—*a*. Mucus-cells. *b*. Protoplasm cells. *c*. Crescents of Gianuzzi. *d*. Transverse section of excretory duct with its peculiar columnar cells. High power. (*Stricker.*)

they are in contact. In other respects the contents of these compound tubular glands are apparently identical with those of the smaller mucous glands of the mouth.

3. *Compound tubular salivary glands.*—The parotid gland of man is built upon the same plan as is the sublingual so far as the arrangement of the tubes is concerned, but its function is quite different, and so also are the characters of the lining epithelia of the convoluted secreting tubes. The epithelial cells of this portion of the tubes are more or less cubical, and are densely granular and proportionately opaque. They contain a round nucleus located near the basement-membrane, and limited by a thin envelope of double contour. The nucleus and cell-body consist of a dense network of fibrils with irregular and small meshes, containing, in the quiescent state, a minimum of fluid substance. During activity, this fluid increases very considerably, and distends the meshes, thus causing the cell to become considerably larger and more transparent. Crescents of Gianuzzi are found in these tubes also, but in fewer numbers than in the purely mucous glands. Another distinction between these purely salivary glands and the purely mucous glands is in the diameter and the size of the lumen of the convoluted tube. In the mucous gland the lumen is distinctly recognizable, of considerable size, and is generally patulous, while, on the contrary, in the purely salivary glands it is often doubtful if the

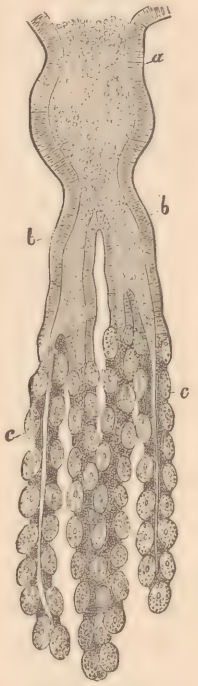
convoluted tube has a real lumen. It is at all times so small and generally so plugged with a substance much like the intercellular cement, that some authors have denied the existence of a true lumen in this portion of the tube, and have claimed that the small intercellular spaces act the part of a duct for the secretions.

In the submaxillary gland of man we have presented a large compound tubular gland still more complicated than either the large purely salivary, as the parotid, or the large purely mucous, like the sublingual, for in this gland the functions and the structure of the two latter seem to be united in one. It is a compound tubular gland of mixed function—the secretion of a salivary fluid and the excretion of mucus, and it combines more or less intimately and perfectly the anatomy of each. Some of the lobules of the gland are composed of convoluted tubules, which possess an entirely salivary character, while others present a purely mucous structure and function. Further, even in the same lobule, some of the convoluted tubes may possess the one character, while others represent the other variety.

4. *Gastric glands.*—In the stomach are two varieties of compound tubular glands, which possess an epithelial lining presenting peculiarities somewhat different from the preceding.

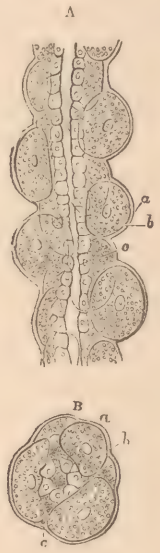
In looking at the mucous surface of the stomach with a good magnifying hand-lens, immense numbers of minute holes can be seen. They are generally collected together in groups of three to five or more. These small holes are orifices of the ducts of glands occupying the thickness of the mucosa. They have been called *peptic glands*. They are constructed upon the model of the compound tubular gland. They consist of a common duct with a wide lumen. The surface of the mucous membrane of the stomach is covered by a single layer of columnar epithelia. During digestion many of these cells elaborate and discharge mucus, and in doing so assume the form of goblet-cells. Columnar cells, identical in appearance with those of the mucous surface, line in a single layer the walls of these ducts. Near the middle of the thickness of the rete mucosa the ducts suddenly narrow and divide into two or more smaller branches, which immediately become constricted, to form the neck or intermediary portion of the secreting tube. The neck of the secreting tube is lined by a continuation of the epithelium in the duct, but the cells are much shorter. Immediately outside of the latter, and between them and the basement-membrane, are scattered here and there single cells of a very granular aspect containing a round or oval nucleus, both cell and nucleus being more or less flattened. They consist of an intra-cellular and an intra-nuclear network, and have been called by some authors *peptic cells* (Figs. 17, 18). They do

Fig. 17.



PEPTIC GASTRIC GLANDS.—*a*. Common duct. *b*, *b*. Its chief branches. *c*. Terminal cæca with spheroidal gland or peptic cells. (*Carpenter.*)

Fig. 18.

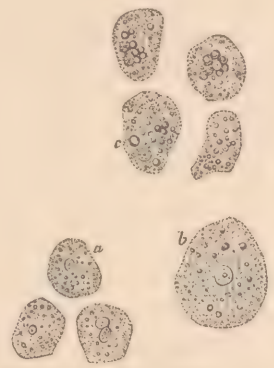


PORTION OF ONE OF THE CÆCÆ OF A PEPTIC GASTRIC GLAND MORE HIGHLY MAGNIFIED: seen longitudinally at A; transversely at B. *a*. Basement-membrane. *b*. Large glandular or peptic cell. *c*. Small epithelial cells surrounding the lumen. (*Carpenter.*)

not constitute a continuous layer. They are more closely aggregated in the neck and upper portion of the secreting tube than towards the fundus, although they are also present in the deepest end of the tube. The secreting tubes into which the large duct divides are somewhat wavy in their course. They are often quite curved at their cæcal extremities. After the constriction of the neck they gradually increase in diameter until the deep end of the tube is reached. As the tube widens the lining epithelium lengthens, still, however, leaving a distinct lumen for the passage of the mucous secretion. The cells of the fundus contain a spherical nucleus in the outer end of the cell, and an intra-cellular and intra-nuclear network whose meshes do not, however, present a linear arrangement such as is seen in the cells which line the neck of the secreting tubes and the common duct. Between the epithelia upon the surface of the gastric mucous membrane is a scant reticulum of branched connective-tissue or endothelial cells. Similar cells and their processes also penetrate the intercellular cement of the whole epithelial lining of the peptic glands.

Liver- and kidney-cells.—The gland cells of the liver possess one, sometimes two spherical vesicular nuclei with an investing membrane of double contour and an intra-cellular and intra-nuclear network. The network appears to be arranged somewhat as a honeycomb. In the spaces of this honeycomb are drops of fat, with biliary granules, and occasionally pigment. The cells are polyhedral from mutual pressure, their outlines generally presenting five or six sides. They are soft, membraneless, and apparently granular.

Fig. 19.



Isolated Hepatic Cells.—*a*, *b*, Normal, but *b* more highly magnified, showing the nucleus and distinct oil-particles; *c*, cells in various stages of fatty degeneration. (*Carpenter.*)

The cells lining the tubules of the kidneys present diverse aspects according to the relative portion of the tubules in which they are located. Those in the convoluted portions of the tubes are more or less granular and opaque. Here they are membraneless, and each contains a round or slightly oval nucleus a little towards the deep part of the cell. The cells are more or less cubical in form with a tendency to a columnar shape. They are longitudinally striated—an appearance due to the presence of large numbers of minute rod-like fibres with a general direction perpendicular to the axis of the tube. These minute rods or fibres are in truth united into a network, the meshes of which are extremely long and narrow. The nucleus also contains a network.

Glands of the skin.—1. *Sweat-glands.* The sudoriparous glands of the cutaneous surface are simple tubes which at their deep portions are very much convoluted. In the straight portion of each tube, as it passes through the derma, there is an epithelial lining consisting of a single layer of more or less cubical or short columnar cells. These cells contain a nucleus, and are more or less longitudinally striated—an appearance due to the presence of an intra-cellular and intra-nuclear network, the prevalent direction of whose fibrillæ is longitudinal. In the convoluted portion the epithelial cells are much less striated, because the meshes of the reticulum of which they are in part composed are much more irregularly arranged.

2. *Sebaceous glands.*—The sebaceous glands consist of two or more lobules attached to an excretory duct. The lobules are as a rule regular, ampullar dilatations, lined with two or more layers of epithelial cells. The peripheral layer of cells rests upon the basement-membrane, and consists of cubical epithelia having spherical or flattened nuclei containing one or more nucleoli. These cells are more or less granular—an appearance due in part to the presence of a fine reticulum in the cell-body and nucleus, and also in part to the presence in the meshes of this reticulum of small fatty particles. The second layer of elements is composed in the main of cells similar to those of the outermost layer, which have undergone a metamorphosis into fat-vesicles. The molecules of fat, which are at first scattered through the meshes of the reticulum, accumulate so rapidly that they distend its meshes inordinately, and finally cause the atrophy and destruction of the nucleus and the breaking-down of the fibres of the reticulum. The small fatty particles then run together and form a large fat-drop, which ultimately bursts its protoplasmic envelope and becomes free in the lumen of the gland.

Hair and hair-follicles.—Epithelium enters into the construction of the shaft and the sheath of hair—structures met with very extensively on the surface of the body. The hair-follicle begins its development in the skin as early as the third or fourth month of the existence of the fœtus. The first stages of development are exactly similar to those of the sweat-gland. Both these organs arise by an ingrowth of the cutaneous epithelium, in the shape of buds, which rapidly extend in length, burrowing their way into the depth of the connnective-tissue; for some time after development has begun, it is impossible to say whether a certain epithelial bud, growing into the connective-tissue, will ultimately form a sweat-gland or a hair-follicle. After the epithelial bud has thus entered some distance, the mass presents the first characteristic indication of the formation of a hair, by a more or less definite appearance of two layers: viz., an axial and a peripheral layer, or the true hair and its investing sheath. By further evolution these two portions, into which the mass of cells filling the depression in the derma has separated, subsequently develop, the axial portion into the shaft, the peripheral portion into the sheath of the hair. After this stage of growth has been reached, the space thus channelled out of the connective-tissue, and filled with the sheath and shaft of the hair, receives definitely the name of *hair-follicle.* The adult hair-follicle normally contains epithelial elements very similar to those of the common epidermis, but presenting some characteristics of form and arrangement which are peculiar to the hairs. Since the hair-follicle, sheath, and shaft are formed by

an infolding of cutaneous surface, the arrangement of the various elements is essentially the same as upon the surface of the skin. The *sheath of the hair* is composed of an inner and an outer portion. The outer portion is a continuation of the rete mucosum of the skin, and consists of epithelial cells identical in structure and arrangement with those of the normal rete mucosum (*b*, fig. 1, Plate II.). Interspersed among these epithelia is a small number of branched protoplasmic cells, in every way similar to those upon the surface of the derma. Internal to the cells corresponding to the rete mucosum of the skin is the inner sheath (*c*, fig. 2, Plate II.). It is composed of two strata of transparent cells, the innermost stratum containing elements with a visible nucleus. Both cell and nucleus are somewhat ovoid in shape, while the cells of the outermost stratum are destitute of nuclei. The latter are, perhaps, a continuation of the cells of the stratum granulosum of the surface, although they contain no granules. Within the innermost sheath, is the axial *shaft* or hair proper, itself covered with a very thin cuticle (*e*, fig. 2, Plate II.). The cuticle consists of a single imbricated layer of thin epithelial scales without visible nuclei (*c*, fig. 1, Plate II.). The hair-shaft comprises two portions when seen transversely, viz., a cortical cylinder and a medullary axis. With its investing cuticle, the shaft, except in and near the hair-bulb at the root of the hair, consists entirely of extremely thin corneous epithelial scales without a vestige of nuclei. They are so densely packed together, that it is impossible, even after mechanical dissociation, to distinguish the outlines of the cells. After the action of sulphuric or nitric acid upon them, the intercellular cement-substance is dissolved, when the thin scales can be readily separated by means of needles, and their characters demonstrated (fig. 4, Plate II.). The corneous cells of the shaft represent, therefore, the stratum corneum of the epidermis. Some of the minute interstices between the corneous scales may contain particles of fatty matter or pigment-granules. The greater or lesser abundance of the latter determine the light or dark color of the hair. Some of these minute capillary spaces may contain air. When many of them are filled with air, and at the same time the pigment particles, previously mentioned, are present only in small numbers or are entirely absent, the hair presents a glistening silvery aspect. The medullary or axial portion of the shaft consists of an irregular aggregation of shrunken epithelia of an original form more or less polygonal. These shrunken angular cells sometimes contain pigment-granules, sometimes minute vacuoles filled with air, and the same gaseous substance generally fills the interstices between the shrunken cells. The medullary axis of the hair-shaft, no matter what the color of the cortical cylinder may be, shines through the latter, presenting a lighter and more glistening appearance.

The foregoing characters of the hair are commonly observed in those portions above the bulb or root of adult hair. As the bottom of the follicle is reached, the distinctions between the inner and outer sheath become lost in the general embryonal character of the epithelium. The hair-shaft is now also changed both in shape and in the character of the constituent elements. It expands into a bulb-shaped extremity a little above the bottom of the follicle. The cuticle covering this *bulb* is composed of slightly granular epithelia containing distinct nuclei. At the bottom of the follicle these cells are more or less spherical, but they flatten and their size and the distinctness of their nuclei lessen gradually from below upwards, as can be seen by reference to the figure already indicated, until, above the bulb, the nucleus is lost entirely, and the cell is converted into the thin transparent cuticular plates or scales already mentioned.

The two portions of the hair-shaft also present in the root an aspect entirely different from that of the outermost end. For a slight distance above the bulb the cells of the cortical cylinder are less corneous and they contain a trace of a nucleus. As the bulb is approached, the epithelia of this cylinder gradually increase in thickness, while their nuclei also become larger and more defined. In the bulb itself, the epithelial cells present the characteristics of the most superficial cells of the rete mucosum.

A vascular connective-tissue papilla springs from the bottom of the hair-follicle and penetrates the centre of the hair-bulb. On the sides, it is ensheathed by the cellular accumulation which is continuous above with the corneous cortical cylinder of the hair-shaft. Above this papilla is a mass of epithelial cells, similar to those of the cortical part of the bulb, which is continuous with the shrunken irregular corneous cells of the medulla or axis of the shaft. These medullary cells of the bulb pass by slow gradations from below upwards into the irregular corneous cells already described as existing in the axis of the hair, but they still present distinct nuclei at a level much higher than that of the bulb. The papilla seems to be the main source of the vitality and growth of the hair.

Destruction and regeneration of epithelium.—The various investing epithelia, of the cutaneous surfaces

and of the mucous surfaces as well, seem to undergo a constant destruction and regeneration. Desquamation is constant upon the external surfaces, and it seems also to be a common although less rapidly occurring phenomenon upon the mucous surfaces. This constant loss of cells must be fully compensated by an active new formation of elements. It is generally conceded that the new supply of cells must come from the layer corresponding to the rete mucosum in the stratified epithelial coverings. Whether these new cells are produced by a proliferation of the soft finely granular polyhedral epithelial cells of the rete mucosum, or whether they arise from the wandering cells which are always present in greater or lesser numbers in the epithelial coverings, or whether they are in part derived in both ways, investigators have not entirely determined. Many uphold one of the extreme opinions, while some defend the middle ground.

It is quite certain that under the influence of irritation not only do the rete cells proliferate, but even those which have begun to approach the corneous condition return to the embryonal state, or exhibit other evidences of an awakened formative power. Under such a stimulus, some of the cells may contain an endogenous progeny. Such a condition is frequently met with in and around tumors, and upon epithelial surfaces secreting pus.

The regeneration upon granulating surfaces of epithelium, or its new formation over abrasions, seems in some way to be more or less closely related to the action of previously existing epithelial cells. The newly formed epithelium is almost always connected directly with the old epithelium at the edges of the wound. If a large abraded surface be sprinkled freely with epithelial scales, isolated islands of newly formed epithelia, which exhibit no direct connection with the epithelium at the edges, may after some time make their appearance.

Skin-grafting.—One means of healing extensive granulating surfaces is, by the employment of skin-grafts. This method is in some respects essentially identical with that of dusting the surface with epithelial scales. In both instances, the presence of epithelium seems to affect the granulation-cells in a peculiar manner, and cause the latter to develop into epithelia. There seems to be an *infection* of the granular cells by the epithelia, or, so to speak, an "action of presence" of the epithelial scales, which is shown in the tendency of the embryonal cells acted upon to form epithelium rather than connective-tissue.

THE CONNECTIVE-TISSUE SYSTEM.

Having reviewed some of the numerous cellular elements which in part constitute the human organism, we now enter upon the consideration of the histological relation which they bear to other constituents. We have already studied the lymph and the blood—tissues which from their derivation may be classed as congeners of connective-tissue.

The connective-tissue, in one form or another, besides special offices which it may perform in the human economy, acts as the framework upon which and within which the various elements and organs are supported. Upon it rests the investing epithelium. In it are imbedded the glands, the muscles, the vessels, and the nerves.

The great connective-tissue system comprises the following groups of tissue, which will be examined in the order in which they are here enumerated: Mucous-Tissue; Varieties of Connective-Tissue, properly so called—Cartilage, Bone, Dentine, and Cementum; Muscle, Nerve, and the Connective-Tissue exhibited in the Bloodvessels and Lymphatics.

MUCOUS- OR GELATINOUS-TISSUE.

In the human adult this form of tissue is of extremely limited distribution. It is found in the vitreous humor of the eye, and perhaps in the enamel-organ of the teeth. In the embryo it is very extensive. It presents two general varieties, which are distinguished by the character of the cellular elements, and the intercellular substance which surrounds them.

The simplest form of mucous- or gelatinous-tissue is that represented by the vitreous humor of the eye. It consists of a transparent, colorless, gelatinous semifluid substance, which contains a more or less considerable quantity of mucin, or of a substance which has a very similar reaction. It is precipitated by weak acids in the form of minute granules, which then give to this semifluid ground-substance under the microscope a finely granular aspect and a slight opacity when viewed by the naked eye. Imbedded in this gelatinous semifluid ground-substance, cellular elements are present in more or less considerable numbers, according to the age of the subject and the quiescent state of the tissue. In the adult they are scattered at rare intervals. These cells are lymphoid elements of more or less spherical or oval outline.

They are capable of limited movements, which, however, are perhaps not usually sufficient for locomotion, although some of them are doubtless wandering cells. They have no limiting membrane; possess one, sometimes two or more nuclei, and consist of an intra-cellular and an intra-nuclear network, which give to the element a more or less granular aspect. The ground-substance seems to be void of bloodvessels in the adult.

Another variety of mucous-tissue, a type of which is met with in the Whartonian jelly of the umbilical cord, has a more complicated structure, and is a grade higher in the scale of development. In a gelatinous mucin-containing ground-substance similar to that of the simplest variety, is to be found a network, or rather felt-work of soft, delicate, slightly refracting fibres. These are collected into bundles or bands, sometimes of considerable width. Upon and near these bundles, cells more or less stellate, and in other respects similar to the flat-branched cells of loose connective-tissue which have already been particularly described, are to be seen, these branches forming by their communications a more or less complete network of stellate cells. Some of the bundles contain, in their interior, bloodvessels with distinct and somewhat thick walls. The inter-fibrillar areas are also sometimes permeated by capillary bloodvessels with large loose meshes, and with strong, distinct walls. These capillary vessels are ensheathed by a network of branched cells. The interfibrillar spaces also contain, in small numbers, the lymphoid cells common to the simplest variety. Sometimes networks, composed of fusiform or of branched connective-tissue cells (fig. 5, Plate II.), are seen occupying the inter-fibrillar spaces. In some pathological formations of mucous-tissue there is, in addition to the foregoing structure, a sparse network of fine single elastic fibres.

WHITE FIBROUS-TISSUE.

Fibrous bundles.—White fibrous connective-tissue is most extensive in its distribution. It consists of extremely fine fibrils collected together into bundles varying widely in thickness and form. These bundles of fibrils may be cylindrical or band-like, the sides of the cylinders or bands being usually parallel. The bundles may be branched, but the individual fibres never are so. The course of the bundles may be straight, or more or less wavy, according to whether they are tense or loose. The minute fibrils which constitute the bundles are united and held together by a transparent viscid cement, which may be dissolved by weak acids, lime-water, baryta water, 10 per cent. solution of salt, and by other means known to the histologist. In some locations, the bundles are

EXPLANATION OF PLATE II.

Fig. 1. A profile view of a Human hair-follicle, containing a hair under a high power. (After Frey.)

a, The fibrous sheath; *b*, the external root sheath; *c*, the cuticle of the hair-shaft; *p*, the papilla of the hair; *h*, *e*, the medullary axis of the hair-shaft; *h*, the cortical cylinder of the hair-shaft; *g*, the transition of the corneous epithelial scales of the cortical cylinder of the hair-shaft above, with the soft, nucleated, and membraneless epithelium of the bulbar portion of the hair; *e*, point of transition of the soft nucleated epithelium of the bulbar portion of the medulla of the hair-shaft into the shrunkened, deformed, and dry corneous granules which fill the medulla of the upper portion of the shaft.

Fig. 2. Transverse section of half of a Human hair, with its root sheaths, still higher power. (After Frey.)

h, Hair-shaft; *e*, hair-cuticle; *c*, two layers of the internal root-sheath; *b*, external root-sheath, showing an outer layer of columnar cells; *f*, basement membrane; *a*, the external fibrous sheath.

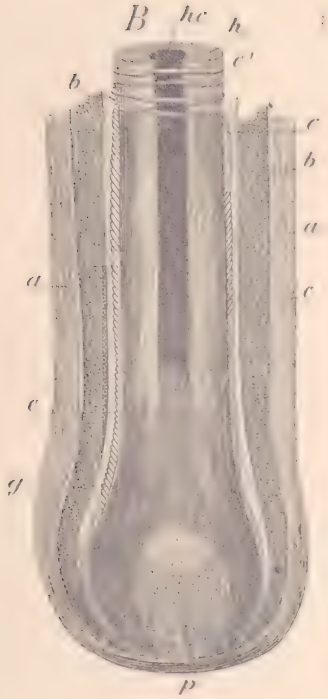
Fig. 3. *a*, *b*, *c*, Stellate mucous-tissue cells, whose processes form a more or less complex network. (Moderate enlargement.)

Fig. 4. Represents isolated cells of various parts of the hair. Highly magnified. (After Frey.)

e, Nucleated epithelial cells of the bulbar portion of the hair; *b*, *h*, cells from the cuticle of the hair; *h'*, corneous epithelial cells of the cortical portion of the shaft, treated with sulphuric acid, the same resolved into separate plates at *h.''*

Fig. 5. Mucous tissue (gelatinous tissue) from the umbilical cord of a Lamb, very highly magnified. (After Ranvier.)

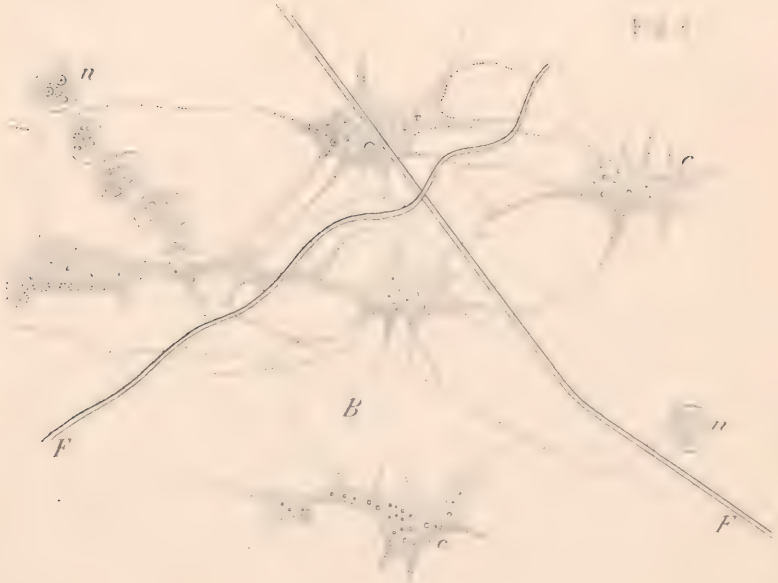
c, Branched cells; *n*, embryonal cells, or lymph corpuscles; *F*, connective fibres; *B*, intercellular amorphous fluid-substance, containing mucin.











T. Sinclair & Son, lith.

more or less completely enveloped in a thin elastic sheath. Such ensheathed bundles are to be found in the subcutaneous connective-tissue, in the subarachnoid of the brain, in aponeuroses, in tendons, and in some other locations.

Structure and arrangement of fibrous bundles.—The bundles of fibrils present a distinct longitudinal fibrillation when seen under a sufficient magnifying power. When they are loose and wavy, they also appear to have an indistinct, transverse striation. This is an optical illusion caused by short and very frequent waves in the course of the fibrils. This wavy appearance of the fibrils, and consequent apparent transverse striation, may be seen sometimes even when the sides of the bundle seem to be perfectly straight.

Water and weak acids cause the interfibrillar cement to swell, and give the bundle a hyaline or homogeneous aspect. These agents have no such effect upon the elastic sheath which envelops some of the bundles. Ensheathed bundles appear swollen in some places, and constricted in others, thus presenting a beaded outline.

The bundles of fibrous tissue may be variously arranged with respect to each other. The simplest arrangement is that of a collection into secondary bundles or bands, which run parallel with each other and are spread out, side by side, to form lamellar membranes, as in aponeuroses, or are collected together to form rounded cords, as in tendons. They may, on the other hand, cross each other in various directions, forming a loose felt-work with wide meshes, as in the loose connective-tissues; for example, the subcutaneous- or mucous-tissue, the inter-muscular connective-tissue, the loose interstitial connective-tissue of glands, etc. Or they may be closely packed together to form a very dense felt-work, such as the cutis, the dura mater, etc.

On the other hand, the bundles may form a loose network spread out in the form of a membrane with more or less wide meshes, like the mesentery, the ligamentum dentatum of the spinal cord, etc.

Interfibrous spaces, and their cellular contents.—The spaces left between the fibrous bundles are consequently of forms varying according to the direction of the bundles. They are filled with lymph, and constitute the radicals of the great lymphatic system.

In tendons, the spaces left between the bundles are more or less linear when viewed longitudinally, and when seen in transverse section appear more or less stellate.

When speaking of endothelia and connective-tissue corpuscles, we described the flat elastic cells which form a partial lining of the lymph-space formed between adjacent parallel bundles of tendons, and stated their relation to the bundles of fibrils upon which they were more or less closely applied. It was then stated that these cells (the flat tendon-plates of Ranvier) spread across two or more bundles. Fig. 2, Plate III., shows very beautifully this peculiar arrangement of the tendon-cells. The drawing represents a number of (primary) bundles united together into a (secondary) larger bundle forming a small tendinous cord in the tail of a young rat. In larger tendons we have a number of such secondary bundles collected together to form the tendon. Tendons of this kind have their external surface covered by a complete layer of large flat endothelial plates such as line serous cavities, which rest upon an extremely thin elastic apparently structureless membrane. Such a tendon, after proper treatment by nitrate of silver, when placed under the microscope and seen longitudinally, shows this superficial covering of endothelial cells. By lowering the focus the flat tendon-cells of Ranvier next come into view. The latter if seen in surface present the appearances already described *à propos* of the cells of the connective-tissue. If their position upon the secondary bundles is such that they are seen in profile, they then appear as lines or spindles with slightly projecting bellies corresponding to the location of the nucleus. When a tendon composed of secondary bundles is cut transversely, and properly stained, it presents a number of more or less markedly stellate bodies (Fig. 20) connected the

Fig. 20.



Transverse Section of Tendon: showing so-called branched corpuscles, inclosing spaces which, left blank, are naturally filled with tendinous fasciculi. High power. (*Carpenter.*)

one with the other by anastomosing branches (*C*, fig. 2, Plate III.). These bodies were formerly regarded as stellate connective corpuscles. They are, in normal tendon, generally nothing more than the cross cuts of the more or less flat tendon plates of Ranvier. These stellate forms may consist of two or more of such plates in apposition. Sometimes even one or more lymphoid

cells may be mingled with them. They may thus be formed of aggregations of cells, in which case several nuclei may be visible within them. The anastomosing branches appear to be sections of the primary or secondary cell-plates and their lateral ramifications. The clear spaces constituting the meshes formed by the previously mentioned anastomoses correspond to transverse sections of bundles of fibrils which have not taken the staining.

Besides the fixed cells above described, leucocytes or wandering cells are found in small numbers in the lymph spaces of the connective-tissue.

Elastic fibres.—When tendons are thoroughly boiled the white fibrous tissue which constitutes them is dissolved, and the other elements previously mentioned disappear. The more complete this effect of boiling, the more visible becomes a network formed of single highly refracting elastic fibres. These elastic fibres are very small in diameter, are more or less perfectly cylindrical, are branched at intervals, and are apparently homogeneous.

Their branches unite to form a network, whose meshes are long and narrow, the long diameter of the meshes being parallel with the axis of the tendon bundles which they accompany. These elastic fibres are in contact with the sheath which envelops the primary bundles more or less completely. They are so difficult to be seen that unless they are specially prepared they are generally invisible.

In *aponeuroses*, where the fibrous bundles are arranged so as to form thin lamellæ of considerable width, the fibres of a given lamella run parallel with each other, and are crossed at an angle by those of the lamella next above or below. In many such lamellar fibrous-tissues, the fibres in adjoining lamellæ cross at right angles. The tendon-cells are then found to be much more irregularly formed than in the simplest variety of tendon. In the adult these cells are not so frequently arranged in rows as in the simple tendons, and the secondary plates which spring from the body of the cell may then have a direction corresponding to that of the different fibrous bundles with which they are in contact.

Loose connective-tissue.—In the loose connective-tissue, for example the subcutaneous cellular-tissue so called, the bundles of fibrils run in every conceivable direction, sometimes branching and forming frequent anastomoses. The spaces left between the fibrous bundles are generally large, and they freely intercommunicate. Fluid or air injected into them readily passes from one to another. After having been distended by air and dried, they present the appearance to the naked eye of large cells or vesicles, hence the name of *cellular-tissue*. Some of the bundles of fibres are ensheathed as already mentioned, many of them are not. The fixed cells of the connective-tissue are not very numerous in adult tissue of this kind. They are loosely applied to the surface of one or more bundles, frequently at their points of crossing (see fig. 3, Pl. IX). The wandering lymphoid cells are much more numerous in this form of connective-tissue than in the tendons or aponeuroses.

Yellow elastic fibres are also to be met with. Here they are frequently much larger than in tendon, but they bear much the same relations to the fibrous bundles in the one case as in the other. The larger elastic fibres have been found by some investigators to be enveloped by a thin, dense membrane, which in most locations is extremely difficult to demonstrate. In the loose subarachnoid connective-tissues of the brain, and in some other locations, this investing sheath is quite distinct.

This variety of fibrous tissue may exist in the form of a thin, fenestrated membrane. Some portions of the omentum furnish an example of such, the fenestræ in this case representing the dilated lymph-spaces existing between the bundles of fibrous tissue. It is thought by some authors (Axel Key and Retzius) that many of the loose connective-tissues are composed of scant felt-works of fibrous bundles spread out in many superimposed lamellæ, which are more or less separated from each other by a single layer of flat endothelial cells resting upon one side of an extremely thin, structureless elastic membrane.

Dense connective-tissue.—The dense felts of white fibrous tissue, as, for example, those of the true skin, of the dura mater, etc., are essentially identical in structure to the loose felts of the subcutaneous connective-tissue, of the submucous-tissue, and of the interstitial connective-tissue of muscles, and of glands. The fibrous bundles being now much more closely packed together, the lymph-spaces are consequently smaller. The cellular elements are also present in much smaller numbers.

Bloodvessels.—The bloodvessels supplying this form of connective-tissue have much the same character as in the fibrous variety of mucous or gelatinous-tissue already described.

There are two other varieties of white fibrous connective-tissue, namely, the *neuroglia* and the *reticular*, or *lymphoid* tissue, which will be briefly considered when we study respectively the nervous system and the lymphatic system.

YELLOW ELASTIC-TISSUE.

Another form of connective-tissue presents itself in the yellow elastic-tissue. The fibres or bands composing it differ in chemical constitution from those of white fibrous tissue. They are not influenced by the action of water, weak acid, or strong alkalies. Unlike the white fibrous tissue, the individual elastic fibres frequently branch, and by the anastomoses of those branches form a genuine network with meshes, varying in size and shape according to the location and the variety of elastic-tissue.

Fine elastic fibres.—As already indicated, every form of white fibrous tissue contains a variable amount of elastic tissue in one form or another.

Perhaps the simplest and most widely distributed variety of yellow elastic-tissue is that which is present among the bundles of white fibrous tissue in the form of a loose sparse network of fine cylindrical apparently homogeneous and highly refracting fibres. These fine elastic fibres lie in close proximity to the (primary) white fibrous bundles, never within them. After nearly every method of preparation they seem homogeneous, presenting no trace of fibrillation or other structure. But when freshly submitted to the action of osmic acid, and examined under a moderately high magnifying power, they appear transversely striated. If a power of eight or nine hundred diameters with a good lens is employed, the transverse striæ are resolved into highly refracting lenticular or somewhat spherical forms, imbedded in a less dense, hyaline, transparent substance.

The fibres of elastic-tissue are straight or curved according to the tense or loose condition of the tissue in which they are found. When broken they curl up at the extremity. This form of elastic fibres is met with also in the matrix of yellow elastic cartilage.

Coarse elastic fibres.—Besides the network formed of such delicate elastic fibres just described, many white fibrous tissues contain an elastic plexus, composed of much coarser fibres. These coarser, elastic fibres are cylindrical or band-like. Schwalbe proved them to be covered by a delicate elastic sheath, which is ordinarily invisible. After the action of osmic acid upon perfectly fresh specimens, the coarse fibres are also seen to possess the peculiarity of structure already described for the finer fibres. This variety of yellow elastic fibres is also met with in the skin and other felt-works of white fibrous tissues. In the superficial portion of the trachea and bronchi they are closely packed together to form, with but a sparse amount of interstitial white fibrous tissue, a dense longitudinal layer. The most marked development of this form of yellow elastic-tissue is found in the ligamentum nuchæ and the ligamenta subflava, which may be regarded as, *par excellence*, types of yellow elastic tissue. Even in these two locations there is always a certain quantity of white fibrous bundles

Fig. 21.



YELLOW ELASTIC-TISSUE.—High power. (*Gray.*)

scattered through the meshes formed by the large yellow fibres, and there are also a small number of the formative connective-tissue cells present. The latter bear their customary relations to the lymph-spaces and the fibres. In this tissue the elastic fibres pursue mainly a longitudinal course, and are closely applied to each other. But if thin sections are made, and pulled out laterally by needles, it is easily seen that they really constitute a network. This form of yellow elastic-tissue is also found well developed in the walls of large arteries and veins.

The elastic networks heretofore considered are more or less sponge-like in their arrangement. There are elastic fibres which are band-like and in some locations form only lateral anastomoses. In this case we have an elastic fenestrated membrane, such as is present in the inner and middle coats of arteries and veins (see fig. 3, Plate III.).

Furthermore, instead of a fenestrated membrane, we may have a continuous layer of yellow elastic-

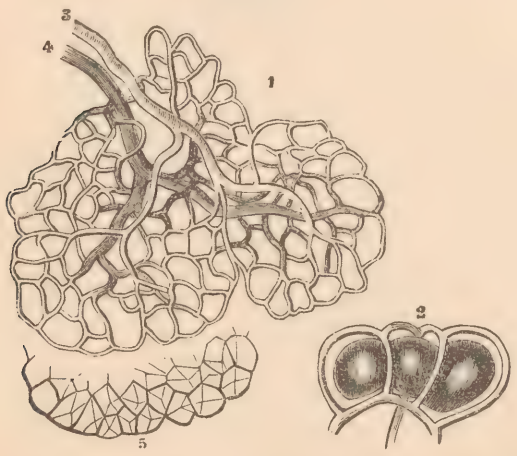
tissue such as is found upon the posterior surface of the cornea, and upon the surface of serous cavities immediately beneath the endothelia. The former membrane (*membrane of Descemet*), however, is known to be somewhat fibrillar in structure, although ordinarily it does not appear so.

The more or less distinct basement-membrane of gland-tubes, as has been already hinted, is an elastic membrane formed sometimes entirely of flat, polygonal or branched, elastic endothelial plates.

ADIPOSE TISSUE.

This is another member of the group of connective-tissues. It may be present in a diffuse manner in the subcutaneous and submucous tissues of the economy. In the well-nourished it is frequently present in the interstitial connective-tissue of muscles and of some glands, and it may be found in greater or lesser quantity in subserous connective-tissues. Fatty or adipose tissue, however, is usually found aggregated into lobules, each one of which generally has its own special vascular apparatus, being supplied by an afferent artery, one or more afferent veins, and an intermediary capillary network of small meshes, in which one or two adipose cells lay (Fig. 22). The aggregation

Fig. 22.



Bloodvessels of Fat.—1. Minute flattened fat-lobule, in which the vessels only are represented. 3. Terminal artery. 4. Primitive vein. 5. Fat-cells of one border of the globule separately represented. (Magnified 100 diameters.) 2. Plan of arrangement of capillaries on exterior of fat-cells, more highly magnified. (*Gray.*)

of the cells into lobules, the possession by each one of these lobules of its own vascular supply, and a mode of development which is similar to that of some lymph-glands, have suggested to some histologists a comparison of this tissue with that of secreting glands. Klein, Creighton, and others consider the lobules of adipose tissue essentially acini of ductless glands. However true or false this assumed analogy may be in fact, there is undoubtedly, up to a certain point, a wonderful parallelism in a common method of development for the adipose lobule and the lymph-follicle.

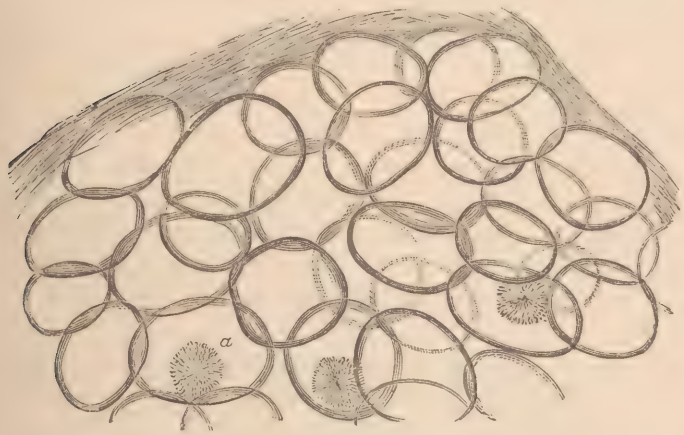
Development and growth of adipose tissue.—According to Klein, and some other accomplished investigators, the origin and growth of a lobule of fatty tissue in the mesentery may be briefly sketched as follows:—

In the vicinity of an artery of somewhat considerable size a small spot can be seen with the microscope, in which the following conditions are present. In the lymph-spaces the flat, fixed cells of the connective-tissue are undergoing proliferation; considerable numbers of lymphoid cells are being formed by division and budding. The connective-tissue septa between neighboring lymph-spaces, in which the cells are proliferating, become gradually thinned until there remains only a delicate reticulum, in the meshes of which are to be found newly-formed lymphoid cells. In other words, a genuine lymphatic reticular-tissue is in process of formation. The spot of reticular-tissue at first forms at some distance from a blood-capillary. After the cellular activity has somewhat progressed, the nearest capillary begins to send out one or more loops towards the little lymphoid spot or nodule. One arm of this loop subsequently grows into an arteriole, the other develops into a venule; the middle portion sends out protoplasmic branches to ramify in the minute nodule of lymphoid tissue. These protoplasmic branches become hollowed out, finally constituting a capillary network, which permeates the newly-formed cellular mass. Often stellate protoplasmic cells in the depth of the nodule have no direct connection with the walls of previously formed or developing capillaries, but, by a process of vacuolation, become hollowed out and finally united with the capillaries to form new bloodvessels. In this manner the newly-formed nodules, after the commencement of their growth, are supplied with newly-formed bloodvessels. Adjacent spots or nodules, by spreading, may unite together to form greater or lesser areas of similar newly-formed cellular tissue of a lymphoid character. At this stage of development we have, as far as the eye can tell, genuine lymphatic or reticular-tissue, such as is seen especially well-defined in the mucosa of the intestines. These spots in the mesentery are always covered, at least on one surface, with a layer of germinating endothelia.

It is after this that the adipose tissue, as such, makes its first appearance. In some of these nodules

or lobules, to use a better term, a larger or smaller number of the cells begin to charge themselves with minute molecules of oil—a circumstance which causes them to become extremely granular and somewhat opaque. These minute fatty granules subsequently coalesce to form fewer and larger fat-drops which now load the cell in varying numbers. These fat-drops in their turn increase in size and finally run together. At this stage of development of the fat-cell we find the element consisting of a cell-body which is spread out over the oil-globule as a thin shell of protoplasm. The nucleus, which has been pushed to one side and much flattened, has an enveloping membrane of double contour, and it contains, as does also the cell-body, a network of fine fibres holding in its close meshes a small amount of semifluid, transparent, structureless substance. The fat continues to accumulate in the cell until the enveloping protoplasmic shell is so stretched and distended that the only visible trace of it to be seen, under the microscope, is in the form of an extremely thin limiting membrane surrounding the oil-globule when the latter is viewed in optical section. This membrane is a little thicker at one side—a single indication of the location and existence of the nucleus. The cell is now known as the adipose vesicle (Fig. 23). In a growing lobule of adipose

Fig. 23.



Adipose Tissue.—*a*, Star-like bodies, from crystallization of fatty acids. High power. (*Gray.*)

tissue the different fat-cells may present various stages of the elaboration of fat. In a fully-developed one, however, all, or nearly all, the cells present the aspect of a fully-developed vesicle. The vesicles rest in the meshes of the rich capillary plexus which surrounds and permeates the lobule. At the periphery of a full-grown lobule a small amount of loose fibrous bundles may be seen between the cells, accompanied by a small number of fixed and mobile connective-tissue corpuscles. In the depth of the lobule this fibrous framework has apparently disappeared, at any rate it is here generally invisible, since only the capillary vessels are to be seen.

Whether the adipose lobules are developed in the mesentery or in the subcutaneous, submucous, or interstitial connective tissues, it is usually after the method above sketched: First, the formation of a lymphoid nodule; then, the supply of this nodule by a special newly-formed vascular system; last, the gradual transformation of the vascularized lymphoid nodule into an adipose lobule.

Diffuse formation of fat.—There is also a not infrequent formation of diffused adipose tissue in the subcutaneous, submucous, and intermuscular loose connective tissue by the direct infiltration and transformation into adipose vesicles, of the fixed and other cells already existing in these tissues. Such a direct transformation of the connective-tissue cells into fat-vesicles may involve wide areas of tissue, and result in the formation of more or less thick and extensive strata of adipose tissue. The large granular plasmatic cells of Waldeyer, which are usually found in greatest numbers in the neighborhood of vessels, very frequently experience this direct transformation or infiltration.

In this latter method of formation, the blood-vessels actively increase, for adipose tissue is pre-eminently a vascular tissue.

The fat once formed, it and the cell containing it may suffer various changes. By an interference with the vascular supply the fat may ultimately decompose, and fat-crystals form in the interior of the vesicles. Or, on the other hand, under the influence of an increased activity of the cell-irritation—in inflammation for example—or of a demand for nutritive material, such as may be occasioned by inanition or fasting, the fat may gradually disappear, leaving in its place at first a serous fluid which still distends the cell and preserves its vesicular form. If the irritation or the demand for nutritive material still continue, this serous fluid gradually disappears and the cell finally returns to the original form it possessed before the fat first made its appearance.

CARTILAGE.

In cartilage we have a structure which has been classed with the various forms of connective tissue, but there seems to be a wide variance between it and other groups of the great connective-tissue system,

both as to its chemical constitution and its intimate structure. While the other groups of the connective-tissues yield gelatine on boiling, the cartilages, on the contrary, yield chondrin. Cartilage consists, like the other tissues, of cells and intercellular substance; the latter is now known as the ground substance or matrix. There are three principal varieties of cartilage which are distinguished from each other by variations in the nature of the matrix rather than in the cells. These principal varieties are hyaline cartilage, reticular or yellow elastic cartilage, and white fibrous cartilage.

HYALINE CARTILAGE.

The simplicity of the structure of *hyaline cartilage* is nearly equal to that of the simplest form of mucus or gelatinous tissue.

Cartilage cells.—The cells are generally more or less spherical or ovoid, when free to assume shapes which are not the result of unequal pressure. They contain one, occasionally two, large spherical vesicular nuclei with a thin limiting membrane of double contour. The nucleus may contain one or more comparatively large and distinct nucleoli. The cell-body often incloses a few small fat drops and fatty granules. The nucleus consists of a network of fibrils similar to the intra-nuclear network of other cells, but the fibrils which constitute, with a semifluid inter-fibrillar substance, the body of the cell, instead of forming a true network as in other cells, are arranged in a dense felt-work with the fibres crossing each other, and interlacing in all directions. The cartilage-cell possesses one characteristic which unmistakably distinguishes it from other cells, and marks the tissue in which it is formed as cartilaginous. It has the faculty of causing a halo to be formed around it of substance similar to the matrix of hyaline cartilage—a more or less thin film known as the capsule. This peculiarity of the cartilage cell, it should be remarked here once for all, is a characteristic of all cartilage-cells, whether of one variety of cartilage or of another. The cartilage cell is capable of limited movement. It can swallow minute particles brought directly in contact with its body, and under the stimulus of physiological growth, or of pathological irritation, can multiply by division. Under the influence of such a stimulus the cell first enlarges; then the nucleus divides by fission or by gemmation; finally, the cell-body suffers a constriction and an ultimate division into new cells, each containing a nucleus. If the stimulus is energetic, each new cell may again divide. Thus two, four, eight, or even sixteen or thirty-two new cells may be formed as the progeny of the original cell. The original cell has been termed the *mother cell*,

EXPLANATION OF PLATE III.

Fig. 1. White fibrous connective-tissue, highly magnified.

a, The fibrous bundles; *b*, nuclei of endothelial cells applied to the surface of the bundles, or of stellate connective-tissue corpuscles resting in the interfibrous lymph spaces; *c*, a lymphatic lacuna.

Fig. 2. *A*. Highly magnified view of an isolated cord of primary bundles of white fibrous tissue from the tail of a young Rat. Fresh specimen, silver-treated. High power.

n, Nucleus of flat endothelial cell-plate applied to the surface of the cord, the cell is seen to spread across two or more bundles; similar endothelial cells are arranged in a row—they do not completely envelop the cord; *f*, fibrous bundles composing the cord.

B. A view, under the same power, of two isolated endothelial cell-plates similar to those which in part cover the fibrous cord in *A*. *n*, The nucleus; *e*, a ridge on the surface of the cell plate, which sinks into the crevice or groove formed by the apposition of two or more bundles.

C. A transverse view, under a much lower power, of several juxtaposed fibrous cords, such as mentioned above. *f*, The fibrous bundles cut across; *c*, stellate bodies, having processes which sometimes communicate with those of neighboring bodies—they have been regarded as stellate corpuscles or cells, but are nothing more than the cross cuts of the above-mentioned endothelial cell-plates. (All after Ranvier.)

Fig. 3. Represents, under a moderate power, an elastic lamina of the middle tunic of the Human aorta. (Ranvier.)

b, Elastic membrane; *a*, elastic fibres arising from it.

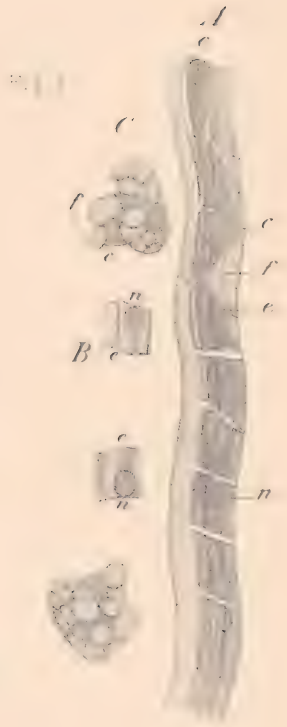
Fig. 4. Hyaline cartilage of Man, medium amplification.

d, Structureless hyaline matrix, in which are imbedded cells enveloped within a capsule, *a*, which latter is indicated by the light halo; *b*, *c*, cells in process of multiplication.

Fig. 5. Section of cartilage from the head of the femur of a Frog, examined perfectly fresh and without any mounting fluid. Very high power. (After Ranvier.)

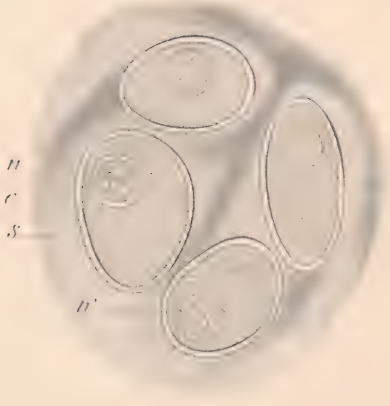
s, Fundamental substance, or hyaline matrix; *c*, capsule; *n*, double-contoured nucleus; *n'*, small brilliant nucleolus.







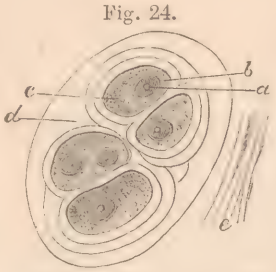




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while the descendants have received the name of *daughter cells*. If the process of division be slow each new cell may form around it a new capsule (see Fig. 24). In this case the mother capsule contains a series of daughter capsules. If, however, the process of multiplication is rapid the newly born cells will not have time to secure the formation of a capsule before they give birth to new cells. Hence, the orginal mother capsule must now contain two or a greater number of cells of a more or less embryonal nature. The healthy cartilage-cell lives, then, within an envelope or shell which it builds for itself as a habitation.

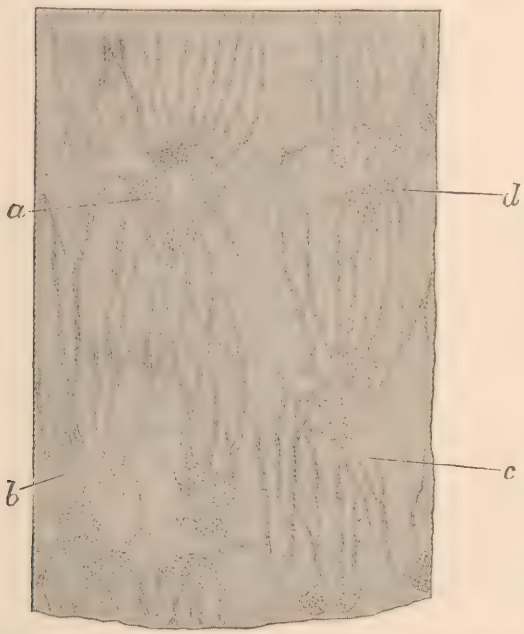
Fig. 24.



PROLIFERATING CARTILAGE-CELLS.—*c*, Protoplasm of the cell; *a*, nucleolus; *b*, nucleus; *d*, primary and secondary cartilage capsules; *e*, ground substance. In one of the cartilage-cells are seen two nuclei.

The inner surface of this envelope, *the cartilage capsule*, forms the boundary of a lymph-space, more or less spherical, which is normally quite filled by the body of the cartilage-cell (see figs. 4, 5, Plate III.). Preparations of cartilage usually show the cartilage-cell to be more or less angular, and occupying only a small proportion of the space within the capsule. This is a distortion, due to the death and shrinking of the cell.

Fig. 25.



CARTILAGE OF A CUTTLE-FISH.—*a*, *d*. Body of cell. *b*. Anastomosing branches of the cells. *c*. Fundamental substance. ×400. (*Ranvier.*)

In the depth of cartilage the capsules usually have a tendency to assume the spheroid form, while towards the surface they become more or less flattened or lenticular in outline. In the superficial layer, at the articular surfaces, the cells are quite flat, and sometimes branched. In the articular cartilages, near the periphery, where the fibrous tissue of the synovial membrane is attached, the cartilage-cells are often branched, and at the line of attachment the processes of the branched cells sometimes communicate with those of the connective-tissue corpuscles of the fibrous tissue. Branched cells, like those seen in Fig. 25, are not uncommon in hyaline cartilage of some lower animals.

Matrix.—The intercellular substance, the ground-substance, or, as it is technically called, the *matrix* of hyaline cartilage, is usually hard, somewhat elastic, homogeneous, and transparent. In adult cartilage, after staining, the matrix faintly shows, by slight differences in shade, very indistinct and shadowy marking for some distance around the capsule (fig. 5, Plate III.). The cartilage-cell seems to have been a centre around which on all sides the matrix has been deposited in successive layers from without inwards, the existing capsule being last deposited. Under some circumstances the shadowy areas around the capsule seem to be composed of a number of concentric shells. The whole ground-substance appears to consist of an aggregation of these shadowy areas surrounding the cells.

Fibrillation of matrix.—Sometimes in adult hyaline cartilage the matrix is seen to be very finely fibrillated. This condition is met with most frequently in the costal cartilages of the aged, and in the calcifying layer of ossification of cartilage (see fig. 1, Plate IV.).

Embryonal cartilage.—The cells of hyaline cartilages may be closely aggregated, or they may be sparsely distributed through the matrix. When the intercellular substance is so small in amount that it is scarcely appreciable, the cartilage is known as parenchymatous or *embryonal cartilage.*

In the deep portion of articular cartilages, in the neighborhood of lines of ossification, the cartilage corpuscles assume an arrangement in parallel rows more or less vertical to the articular surface.

Perichondrium.—Each variety of cartilage is enveloped in a fibrous membrane, the *perichondrium*, which covers it everywhere except upon the articular surfaces and in the lines of ossification.

Calcification of cartilage.—Cartilage may be infiltrated with *calcareous particles.* When this is the case lime granules, minute and more or less angular, are first deposited in the ground-substance, immediately around the cartilage capsules. From these points the

infiltration may gradually spread until the whole matrix may be incrusted, and the cells transformed into calcified elements. By transmitted light the particles of lime are dark and opaque, large collections of them consequently appear more or less black. By reflected light they are brilliant and shining. This deposit of lime does not appear to permanently change the constitution of the cells or matrix. Weak acids readily dissolve it, leaving both apparently in their original condition.

YELLOW ELASTIC OR RETICULAR CARTILAGE.

This variety of cartilage is met with in man, in the Eustachian tube, in the epiglottis, and a few other places. It differs from hyaline cartilage only by the presence in the matrix of fine, yellow elastic fibres in greater or lesser numbers. These fibres are generally collected together so as to form a trabecular network in the matrix. In the meshes thus formed the cells are found enveloped in capsules, which are surrounded by a variable amount of hyaline ground-substance (see fig. 3, Plate IV.).

Near the perichondrium the elastic fibres gradually disappear.

WHITE FIBROUS CARTILAGE.

This form of cartilage appears to occupy, histologically, an intermediate place between white fibrous connective-tissue and hyaline cartilage.

Its distribution in man is somewhat more extensive than the yellow elastic cartilages. It is chiefly found in the intervertebral disks and in the bursæ of tendons.

The intercellular substance or the matrix consists of white fibrous tissue arranged in parallel bundles. Frequently the fibres are arranged in lamellæ, and sometimes, as in the intervertebral disks and the symphysis pubis, the bundles constituting the lamellæ have a concentric arrangement. The cells of this form of cartilage have the same relation to the bundles as the flat cells of Ranvier do to the parallel bundles of tendons or aponeuroses. The cells themselves are not quite so flat or so much branched as the endothelial cell-plates of tendons. They are enveloped by the characteristic capsule of the cartilage-cell (fig. 2, Plate IV.). In some places the capsules are surrounded by a very small amount of hyaline substance. In the transition of tendon into fibro-cartilage the tendon-cells gradually thicken and become invested with a capsule, the only visible change noticeable. In the transition of fibro-cartilage into hyaline cartilage, as is observed at the edges of the intervertebral cartilages for example, the fibrous intercellular substance slowly disappears and merges in the hyaline matrix, while the cartilage-cells gradually swell and approach the spherical form.

Lymphatics of cartilage.—Cartilage, like all the other connective-tissues, is permeated by *lymph spaces*. The cartilage-capsules are perforated by almost numberless minute canals. The openings of these minute capillary tubes or pores communicate at one end with the interior of the capsule, which is a lymph-space containing the cartilage-cell, and at the other end open into large canaliculi which ramify in the cartilage matrix, and which, in their turn, communicate with the lymphatics of the perichondrium.

BONE OR OSSEOUS TISSUE.

Bone is the greatest in weight of all the solid tissues of the organism, and is the most extensive of the groups of the great connective system.

It presents for study a ground-substance, inclosing cellular elements and vessels, both lymph and capil-

EXPLANATION OF PLATE IV.

Fig. 1. Section of calcified and fibrillated hyaline cartilage, from the costal cartilage of an old Man. High power.

a, Intercellular matrix infiltrated with minute calcareous granules, they are found more densely aggregated at *c*, around the cartilage capsules; *b*, fine fibrillæ, imbedded in the intercellular hyaline matrix.

Fig. 2. Fibro-cartilage from the intervertebral disk of Man. High power.

a, Fibrous matrix or intercellular substance; *c*, *b*, cells contained within a cartilage capsule, and exhibiting various stages of multiplication.

Fig. 3. Reticular or elastic cartilage, from the epiglottis of Man, showing the so-called cartilage cells in various phases of division within their enveloping capsules. High power.

b, Elastic fibres imbedded in the intercellular matrix.

Fig 1

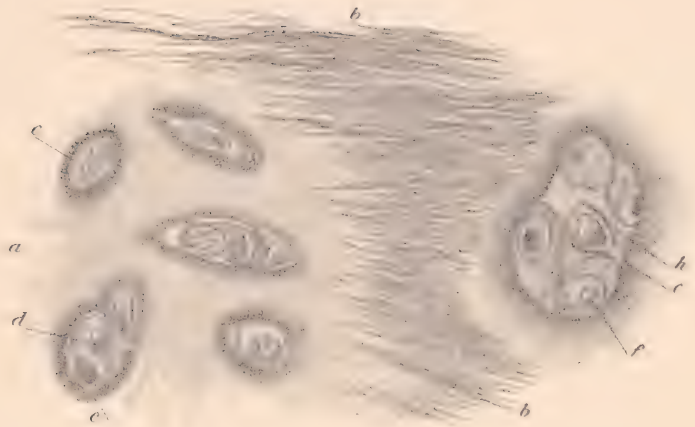
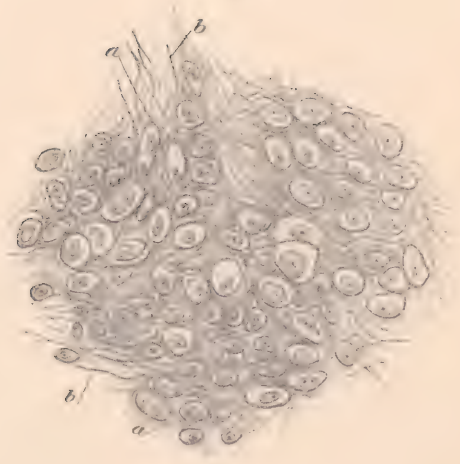


Fig 2



Fig 3



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lary. The ground-substance is dense and compact, as at the boundary of the medullary canal of long bones, and at the periphery of both long and flat bones; or, on the other hand, it is porous or spongy, as in the diploë of flat bones, in the interior of epiphyses, and between the outer and inner compact layers of the diaphyses of long bones.

Compact bone.—The ground-substance of compact bone is hard and brittle, owing to its infiltration with salts of lime, which in the fluids of the body are ordinarily insoluble. They are, however, readily dissolved by the employment of acids. After decalcification through this means, bone may readily be cut into thin sections and stained. Thin plates of the hard, brittle bone, may also be obtained by grinding. A transverse section of the compact substance of the shaft of a long bone prepared by the latter method, and mounted dry, presents an appearance, when examined under a high power of the microscope, which is very fairly represented by fig. 1, Plate V.

Haversian canals.—The ground-substance is permeated by a number of small canals, the *Haversian canals*, which have a general direction mainly parallel with the axis of the shaft. They intercommunicate by means of short transverse or oblique branches, thus forming a network of elongated, and more or less rectangular meshes. The Haversian canals convey a capillary bloodvessel and one or more lymph-vessels, besides a variable amount of delicate, loose connective-tissue of a reticular variety, inclosing cellular elements,—a tissue essentially identical with the bony marrow which fills the Haversian spaces of spongy bone.

Arrangement of bony lamellæ.—Between the Haversian canals of compact bone the *ground-substance* is arranged in the following manner: Immediately around the canal the bony fibrous tissue shows from four to fifteen or twenty *concentric lamellæ*, the number varying according to the age of the formation. The greater the age the more numerous are the concentric lamellæ. The Haversian canals, with their surrounding concentric lamellæ, are known as the *Haversian systems*. Between, and separating the Haversian systems, the ground-substance is constituted by what have been termed the *interstitial lamellæ*. They comprise bands of osseous substance of variable width, running in various directions. Among these interstitial lamellæ of variable direction are some bands of lamellæ which pursue a course in general parallel to the periosteal surface of the bone. These are known as the *parietal lamellæ*. Running among the interstitial and the parietal lamellæ are sometimes found a small number of scattered elastic fibres which are very difficult to demonstrate. Interlacing with the parietal and interstitial lamellæ are found a few small bundles whose basis is white fibrous tissue, and whose direction is more or less perpendicular to that of the lamellæ which they penetrate (see fig. 3, Plate V.). They are called *perforating fibres*, or *fibres of Sharpey*, and are supposed to be the remains of bundles of white fibrous tissue originally forming a part of the inner layer of the periosteum, for at the periphery of the bone similar fibres are continuous with fibrous bundles belonging to the inner layer of that covering.

In flat bones or in thin bony plates, the compact substance presents essentially the same features. The arrangement of the Haversian systems, however, is by no means so regular as in the diaphyses of long bones.

Bone corpuscles.—Between the bony lamellæ of these different systems are numbers of *lymph-spaces*, in which lay connective-tissue corpuscles, just as in other forms of lamellar fibrous tissue. These lymph-spaces and their cellular contents constitute the so-called *bone-corpuscles*. Each lymph-space is in communication with its neighbors by means of minute *canaliculi*, the branches of the so-called bone-corpuscle. These canaliculi penetrate the bone lamellæ, and pass through them, usually nearly perpendicular to the direction of the latter. When a thin preparation of compact bone is made by grinding, and the thin plate is mounted dry, these lymph-spaces and their canalicular branches are filled with air, and by transmitted light consequently appear dark upon a light ground. In Haversian systems cut transversely, the body of the bone-corpuscle is seen in profile, and consequently presents an ovoid or fusiform outline, the long axis being parallel with the course of the lamellæ. The canalicular branches, more or less straight, and running perpendicular to the length of the concentric lamellæ, give to the Haversian systems a beautiful striated aspect, the fine striæ radiating from the Haversian canal as a centre. In the interstitial and parietal lamellæ the canaliculi produce a visible transverse striation. The canaliculi, besides forming an intercommunication between the lymph-spaces of the ground-substance, also bring them into connection with the lymph-vessels of the Haversian canals.

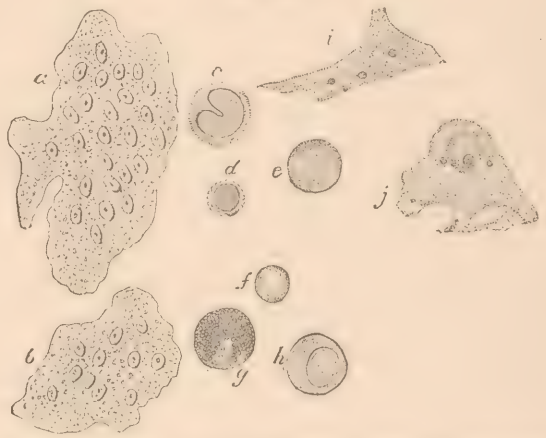
When a so-called bone-corpuscle with its canalicular branches is isolated from the surrounding bony substance in which it is imbedded, and is properly treated, it is found to consist of an elastic shell forming a branched lymph-space. Within this branched lymph-space floats a flat connective-tissue cell similar

to the flat branched cells of loose connective-tissue. This is really the *bone-cell.* Its structure is identical with that of the connective-tissue corpuscle. It gives off delicate branches which enter and pass some distance along the minute canaliculi.

Spongy bone.—The *spongy portion of bone* offers a gross formation quite different from that which we have just studied in the compact tissue. In the latter, the Haversian canals occupy a small area in proportion to that of the intervening ground-substance, and contain a minimum of marrow-tissues. In the spongy substance, on the contrary, the bony matter is small in amount compared to the area of the spaces which correspond to the Haversian canals of the compact tissue, but which here are called *Haversian spaces.* Moreover, the Haversian spaces are filled by a cellular mass, known as the *bony marrow*, in which numerous bloodvessels with extremely thin and delicate walls ramify. The large Haversian spaces are not surrounded by concentric lamellæ, but are separated from each other by more or less delicate trabeculæ of bone which represent the interstitial and parietal bands of the compact substance, and which have a minute structure identical with them. These bony trabeculæ form a loose spongy osseous network in the meshes of which rests bone marrow.

Marrow of bone.—The marrow of bone is an extremely vascular, cellular tissue which presents two chief varieties, the yellow and the red. The *yellow marrow* of bone is especially found in the central cavities of the long bones. It consists mainly of fat-vesicles such as are met with in adipose tissue, and it is the fat-cells which give the tissue its yellowish color. Among these adipose vesicles are a variable number of other elements. A few flat, more or less branched connective-tissue cells together with a sparse amount of delicate connective-tissue fibres sometimes form thin septa between the vesicles. There are also in the latter location a small number of cellular elements, which,

Fig. 26.



CELLS FROM THE MARROW OF BONE DURING THEIR PERIOD OF DEVELOPMENT.– *a*, *b*. Multinuclear "giant cells" (Frey). *e*, *f*, *g*. Lymph-cells from the marrow of the tibia of the Guinea-Pig, examined in the serum of the blood; *c*, *d*, *h*, after the action of alcohol and water 33 per cent. *i*, *j*. So-called osteoblasts from the femur of a new-born Dog, after the action of alcohol 33 per cent. High power. (*Ranvier.*)

EXPLANATION OF PLATE V.

Fig. 1. Transverse section of compact substance of shaft of a long bone of Man. High power.

a, The circumferential or peripheral lamellæ, whose course is, in the main, parallel to the surface of the bone; *b*, the concentric lamellæ constituting the Haversian systems, in the centre of which are the Haversian canals, *f*, *g*; another system of lamellæ is represented at *c*, *d*, the interstitial or intermediate lamellæ; *h*, bone corpuscles, with their radiating canaliculi.

Fig. 2. Longitudinal section of similar bony tissue. Same power.

a, Haversian canals; *c*, their walls; *d*, bone corpuscles, separated by the bone lamellæ, whose direction is usually parallel with that of the Haversian vessels.

Fig. 3. Some of the bony lamellæ from an intermediary or interstitial system, forcibly stripped off after decalcification of the bone, showing the bone corpuscles, and the fibres of Sharpey, *c*.

Fig. 4. Vertical section of the deep layer of ossifying portion of a metatarsal bone, showing some of the phases of development of bone from cartilage. High power. (After Müller.)

a, Cartilage cells, arranged in rows, some with shrunken cell bodies; *b*, ground substance of the cartilage; *c*, medullary canal in process of formation, and containing vessels and medulla cells; *d*, the remains of the ground substance of the cartilage, covered by a thin layer of newly-formed bone, *g*; *e*, osteoblasts covering the recently formed bone; *f*, a bone cell in process of forming a bone corpuscle, still connected with the osteoblastic layer of cells; *k*, recently developed bone corpuscle, containing a young bone cell; *m*, a medullary space, from which the contents have been displaced.

Fig. 1.

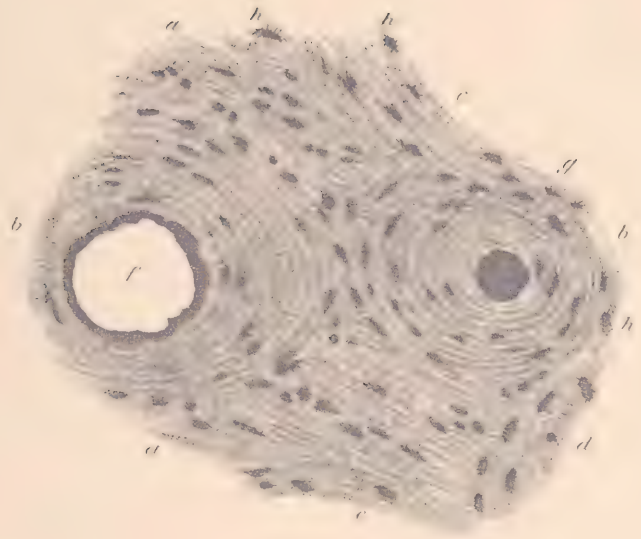


Fig. 3.



Fig. 2.



Fig. 4.



W. Sinclair & Son, lith.

by their size and structure, cannot when isolated be distinguished from colorless lymph-corpuscles. The smallest of the latter have been called *medulla cells* (*d*, *f*, Fig. 26). *Multinuclear giant cells* (myéloplaxes, *a*, *b*, Fig. 26) are also present in small numbers. The latter elements consist of a large, soft, membraneless, irregularly-formed, sometimes branched and flattened cell-body, of a fine granular appearance, and contain a fibrillar network like that of other cells. They inclose a large number of nuclei. The vessels are similar to those of the other varieties of marrow.

Red marrow of bone is met with in the Haversian spaces of spongy bone. To the naked eye it differs from the yellow marrow mainly by the entire absence of fat vesicles, or by their presence only in very small numbers, and by the extreme vascularity of the tissue. This form of marrow consists of reticulated fibres similar to those of lymph-glands or lymphoid tissues to be described later. In the meshes of this reticulated tissue, cells of the following forms are closely crowded: 1st, perhaps an extremely few fat-cells; 2d, large numbers of medulla-cells; 3d, considerable numbers of multinuclear giant cells; 4th, polynucleated cells, which have a diameter slightly larger than that of the red blood-corpuscles, and which possess a smooth, apparently homogeneous body presenting a yellowish-green tinge, — these cells, according to Neumann and Bizzozero, subsequently become converted into red blood-corpuscles, by losing their nucleus and becoming bi-concave; 5th, along the osseous trabeculæ are a single row of cells, which are larger than the ordinary colorless elements of the marrow, and are more or less prismatic or flattened by mutual pressure. They have been called by Gegenbauer *osteoblasts*, since they seem to take an active part in the formation of the bony substance.

All of the foregoing cellular elements possess, in a more or less active degree, the power of movement.

Besides the cellular forms already described there are always present in the bony marrow some colored cells, which are not distinguishable from red blood-corpuscles.

Red bone-marrow is very richly supplied with bloodvessels, which have extremely thin and delicate walls.

Periosteum.—The external surface of bone is covered by a fibrous membrane—the *periosteum*. It consists of two layers, an outer and an inner. The outer layer is composed of one or more lamellæ of dense white fibrous tissue, the direction of whose bundles is parallel to the surface of the bone. Among these white fibrous bundles is a limited quantity of fine yellow elastic fibres, and in the lymph-spaces formed by the apposition of the bundles are cellular elements similar to those of dense, white fibrous tissue. In this external, or *fibrous* layer of the periosteum, blood and lymph-vessels ramify and form networks.

The *inner* or *osteogenetic layer* of the periosteum consists of an extremely loose fibrous tissue, the meshes of which are filled by cells very similar to the osteoblasts described as existing upon the trabeculæ of spongy bone. Among these are numbers of elements which present characters similar to those of lymph-corpuscles. The osteogenetic layer of the periosteum is richly supplied by bloodvessels, which run among the cells occupying the meshes.

Beneath the periosteum the surface of growing bone is covered by a bony network, the meshes of which are crowded by cells which are contiguous with those which fill the inter-fibrillar spaces of the osteogenetic layer. Here and there the most superficial portion of this bony network sends a pointed and somewhat curved spicule of bone into the depth of the osteogenetic layer of the periosteum. The points of these somewhat conical spicules are usually continuous with fibrous bundles of the osteogenetic layer. The surface of the trabeculæ forming this osseous network, as well as of the bony spicules which project into the osteogenetic layer of the periosteum, are covered by the so-called *osteoblasts* of Gegenbauer, through the agency of which not only the bony trabeculæ and spicules springing therefrom increase in size, but also the fibrous bundles at the end of the spicules are converted into bone. In this manner the bone grows beneath the periosteum.

OSSIFICATION.

Bones increase in length by a process which is known as *ossification*. In young growing bone, the epiphyses are united to the diaphyses by the intervention of a plate of cartilage—the *intermediary cartilage*. The successive conversion into spongy bone of the layers of this cartilage which are in immediate apposition with the diaphysis, furnishes an excellent opportunity to examine the process of ossification of cartilage.

Line of ossification.—A longitudinal section passing through the diaphysis and intermediary cartilage of a long bone shows to the naked eye a straight line of union between the spongy bone and the cartilage. This line is called the *line of ossification*. The cartilage above it seems to be divided more or less dis-

tinctly into three layers—the lowest layer or the one forming the line of ossification is more or less opaque, the middle layer is unusually transparent, the upper layer is quite normal in appearance. If a thin piece of the spongy bone and cartilage is shaved off, and after being properly prepared for examination, is placed under the microscope, the following appearances may be noted (see fig. 4, Plate V.). In the upper layer or zone of cartilage, the capsules and intercellular ground-substance are normal. In the middle layer, the cells have begun to enlarge and to multiply. Some of them show signs of disintegration, and the spaces which contain the cells have also considerably increased in dimensions. The increase is mainly in a direction perpendicular to the line of ossification, and on account of this tendency the cells are applied against each other so as to form linear rows. The intercellular substance is consequently encroached upon and somewhat softened.

In the lower zone, the cartilage matrix which remains between the now greatly elongated capsules, in consequence of the further enlargement of the latter, is reduced to narrow trabeculæ which are infiltrated with calcareous deposits. The enlarged elongated capsules frequently fuse together. They are now in part filled by an embryonal marrow. The cartilage-cells which occupy their upper ends approach a wedge-shape, and are piled upon one another in such a manner that the bases alternate with the spaces as seen at *a*, fig. 4, Plate V.

In a yet lower zone, the linear spaces between the narrow trabeculæ of cartilage matrix are completely filled with a mass of cells similar in every respect to that of the bony marrow in the Haversian spaces, and they are now permeated by loops of capillary blood-vessels, which are in communication with the vessels of the marrow of the spongy bone below. The thin trabeculæ of cartilaginous matrix, separating these spaces, are still infiltrated with calcareous salts. They are now more or less completely encrusted with a thin layer of osseous substance of variable thickness (see *g*, fig. 4, Plate V.).

This thin osseous incrustation is itself covered by a layer of osteoblasts of a prismatic, ovoid, or sometimes slightly-branched outline. Here and there in the thickest points of this incrusting layer of osseous substance an oval-shaped, incompletely-branched bone-corpuscle is visible. By carefully searching along these incrustations pouch-shaped notches are occasionally met with opening upon the surface. These are filled by osteoblastic cells which may be connected with other cells in the osteoblastic layer by broad or narrow branches (see *f*, fig. 4, Plate V.). It is thus seen that the bone-cells are osteoblasts which have become included and completely imbedded in the osseous substance which they have formed around them.

In a still lower zone, we recognize the same general features presented by that last described. But the lamellæ of bone incrusting the cartilaginous trabeculæ are much thicker, and the cartilage matrix has entirely disappeared in many places.

Below this zone, there is no trace of cartilage matrix, and we have only the ordinary structure of spongy bone. The spongy substance thus gradually encroaches upon the intermediary cartilages until they finally disappear. The line of ossification presents essentially the same features whether the cartilages be intermediary plates between diaphyses and epiphyses, or cartilages which cover articular surfaces.

It is then noticeable, that in the growth of spongy bone at the expense of hyaline cartilage, the latter does not really become bone, is not really ossified, but is gradually *substituted and replaced* by bony substance which is the direct product of some of the cells belonging to the marrow contained in the Haversian spaces of the spongy bone. This latter tissue is more or less directly an outgrowth from the osteogenetic layer of the periosteum.

It may be stated in general terms that there is no ossification which does not come either directly or indirectly from the periosteum or from similar membranes which represent it. The perichondrium which envelops cartilage as the periosteum does the bone, may be regarded as such a representative, for the structure of the one is similar to that of the other, and their functions are parallel.

DEVELOPMENT OF BONE.

The original development of bone almost always is accomplished through the intermediation of cartilage. The bones of the face, however, and some of those of the cranium, are built directly upon fibrous membranes as a foundation. But whether or not cartilage be employed in the process of development, the formation of bone always starts from the periosteum.

In the embryonal cartilage which nearly always precedes the formation of bone, we have areas wherein certain changes take place preliminary to the development of bone. These areas have been called *points of ossification.* When these points of ossification appear in cartilage we have a development of what has been termed *endochondral bone.*

ENDOCHONDRAL BONE.

In an embryonal cartilage which is preparing to be replaced by bone, the following succession of alterations may be observed.

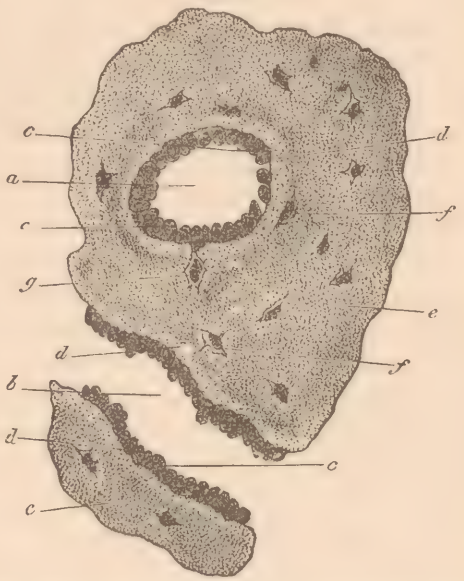
Formation of embryonal spongy bone.—At a certain point in the inner or chondrogenetic (osteogenetic) layer of the perichondrium, a loop or two of capillary bloodvessels project into the cartilage-substance. In advance of these loops the cartilage-cells are enlarging and multiplying within their capsules, which also are enlarged. These cells finally absorb the cartilage-matrix between them and the mass of cellular elements which surrounds the projecting capillary loops; they then communicate with the cells of the osteogenetic layer. By a continuation of this process of absorption of the cartilage in front of the advancing capillary loops, and by the addition of the contents of the capsules to the mass of cells surrounding the vessels, the embryonal cartilage becomes channelled by vascularized cellular trabeculæ or granulations springing from the inner layer of the perichondrium.

The next step everywhere in the close vicinity of the vascular granulations, is the enlargement of the cartilage-capsules, and the multiplication of their cell-contents. This enlargement continues, and results in the intercommunication of many adjacent capsules and the connection of their contents with the vascular granulations. By the enlargement of the spaces containing the cartilage-cells, the intervening ground-substance is eaten away until nothing is left of it but an irregular network of anastomozing trabeculæ, the surfaces of which are notched at the place where the capsules have communicated with the general cellular mass. At the same time the cartilage-matrix in this riddled area is infiltrated with a deposit of the insoluble salts of lime. We have now an area more or less irregular of calcified, spongy cartilage, the meshes of this spongy formation being filled with a vascularized marrow, similar in constitution to that already described when discussing the encroachment of spongy bone upon the intermediary cartilage.

The next step is the incrustation of the calcified cartilage-trabeculæ with a thin envelope of osseous tissue. This first takes place near the central portion of the spongy area, and the bone is formed through the agency of osteoblasts which cover the trabecula. This process advances until the whole cartilage is converted into spongy bone. (Fig. 27).

Formation of bony marrow.—Sooner or later, in the central portions of this embryonal spongy bone, the osseous trabeculæ soften and disappear (*osteoporosis*). In this manner a central marrow cavity results. The spongy bone continues to be slowly absorbed, and converted into marrow until finally the whole of the embryonal spongy bone may be thus absorbed.

Fig. 27.



TRANSVERSE SECTION FROM THE FEMUR OF A HUMAN EMBRYO ABOUT ELEVEN WEEKS OLD.—*a.* A medullary sinus cut transversely. *b.* Another, cut longitudinally. *c.* Osteoblasts. *d.* Newly formed osseous substance of a lighter color. *e.* That of greater age. *f.* Lacunæ, or blood-corpuscles, with their cells. *g.* A cell still united to an osteoblast. (*After Gegenbaur.*)

At the same time that the embryonal spongy bone is being absorbed at the centre, there is a continual new formation of spongy bone by the osteogenetic layer of the perichondrium (which latter may now be regarded as a periosteum), practically identical with that already described for the periosteal growth of bone.

In the older portions of *periosteal* spongy bone, Haversian systems and canals begin to form through the successive development of concentric lamellæ within the Haversian spaces, by means of the osteoblasts which cover their surfaces. Layer within layer is thus formed in concentric deposits until the Haversian space is converted into a Haversian system with its narrow central canal. The original osseous trabeculæ, which formed the meshes of the periosteal spongy bone, persist as interstitial bands between the Haversian systems.

Absorption of bone (*Osteoporosis*).—Around the central marrow-cavity, which has been formed as indicated above, a process of absorption is at work. The compact tissue is disappearing, and being reconverted into spongy tissue through the absorption of the Haversian systems and their substitution by bone-marrow. The

process of absorption does not stop at the accomplishment of this result. The interstitial osseous trabeculæ of the spongy bone next succumb, and the softened area is added to the central cavity.

Thus it is that while the bones are growing at the periphery they are being eroded at the centre.

According to Kölliker, Rindfleisch, Klein, and others, solution of bone is effected by the agency of the multinuclear giant-cells. These cells have consequently received the name of *osteoclasts*. They are believed to elaborate an acid by whose action the bony substance with which they are in contact is first softened and then dissolved.

In the development of bone, the various stages in the process of ossification may succeed each other with varying rapidity in different bones, and in different parts of the same bone. In long bones, for example, the middle portion of the diaphyses often entirely consists of periosteal bone, while at the extremities the embryonal spongy bone has scarcely begun to disappear.

INTERMEMBRANOUS BONE.

The intermembranous formation of bone is analogous to the development of bone from the periosteum. For instance, the bones of the cranium have their origin in a fibrous membrane which soon presents a division into two layers similar both in structure and function to the outer and inner layers of the perios-

Fig. 28.



Osteoblasts from the Parietal Bone of a Human Embryo Thirteen Weeks Old.—*a*. Bony septa, with the cells of the lacunæ, or bone-corpuscles. *b*. Layers of osteoblasts. *c*. The latter in transition to bone-corpuscles. Very high power. (*Gegenbaur.*)

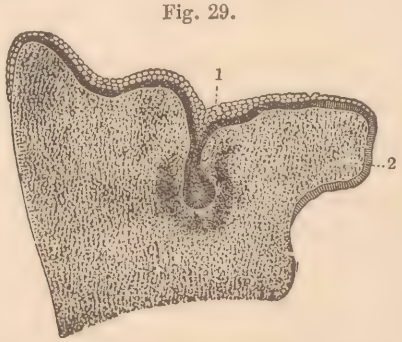
teum. Spongy bone is formed by the inner or osteogenetic layer precisely in the same manner as it is formed beneath the periosteum of other bones. This spongy bone is converted into compact substance by the same method, and finally osteoporosis progresses in a manner already familiar.

TEETH.

Although the first rudiments of the teeth are offshoots from the epithelium covering the surface of the gums, and although the enamel which covers the exposed surface of the fully-developed tooth is of epithelial derivation, yet the greater portions of the teeth, namely, the dentine, the cement, and the pulp, are of connective-tissue origin, and may properly be classed with the connective-tissues. Because of the entrance of bone into their structure, as well as for other reasons, an examination of their histology would seem to have an appropriate place after the study of bone.

Development of the teeth.—The first rudiment of the tooth is met with early in embryonic life, at a period when the connective-tissue of the gum has scarcely advanced in development beyond the state of fibrous mucous-tissue. It is observed in the form of a club-shaped duplicature of the stratified epithelium of the gum. (See Fig. 29.) This epithelial infolding is con-

Fig. 29.



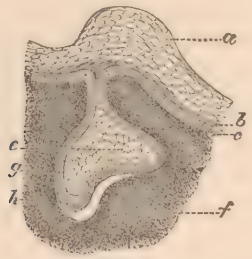
Vertical Section of the Upper Jaw of a Fœtal Sheep, about 2¾ inches long, showing the enamel-germ, with the semilunar rudiments of the dentine-germ and dental sac in transverse section. 1. Dental groove; 2. Palatal process. Magnified 50 diameters.

stituted externally by a single layer of columnar epithelia, identical with those which form the deepest layer of the covering of the gum, and internally by a collection of polyhedral epithelial-cells. These cells, like those of various other epithelial coverings, are held together by an intercellular cement-substance.

This club-shaped mass of epithelial cells is the *primary enamel-organ*. Later this club-shaped mass penetrates deeper into the connective-tissue and increases greatly in thickness, at the same time changing its outline. The club-shaped extremity has now spread out and become indented by a slight elevation of the connective-tissue which has begun to advance into it. (See *f*, Fig. 30.) This elevation is the first appearance of what will subsequently constitute the dentine and the pulp of the tooth. The milk, or first teeth, are now

in full process of development. A preparation for the growth of the permanent teeth is, even at this stage, often to be met with in the shape of an offshoot from

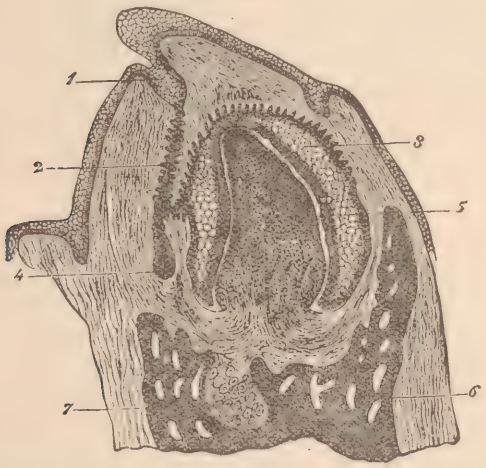
Fig. 30.



Same, at a Later Period of Development.—*a*. Epithelium. *b*. Younger layer of epithelium. *c*. Inferior layer of the epithelium. *e*. Enamel-organ. *f*. Dentine-germ or papilla. *g*, *h*. Inner and outer layers of the sacculus that is about to form. (*Carpenter.*)

the epithelial mass already spoken of as the primary enamel-organ. 4, Fig. 31, represents such an epithelial

Fig. 31.



Vertical Section of the Lower Jaw of a Human Fœtus, measuring about four inches in length, magnified 25 diam. 1. Dental-groove. 2. Remains of the enamel-germ. 3. Enamel-organ of a deciduous tooth, presenting epithelium on both its outer and inner surface, *i. e.*, where it lines the sacculus and where it covers the papilla. 4. Enamel-germ of the permanent tooth. 5. Dentine-germ. 6. Section of inferior maxilla. 7. Meckel's cartilage. The dental sacculus will be observed to present a number of fine papillæ opposite the dental papillæ. (*Carpenter.*)

offshoot after the changes in the growth of the milk-tooth have so far progressed that the connection with the enamel-organ of the latter has been severed.

Fig. 31 represents a much later stage in the formation of the tooth. The connective-tissue papilla has grown into the enamel-organ until the latter has been completely invaginated. The enamel-organ now covers the apex and sides of the tooth-papilla like a cap, and it has been cut off from its former connection with the epithelial covering of the gum. This cap-shaped epithelial mass is termed the *secondary enamel-organ*. Through the invagination of the epithelial mass constituting the enamel-organ, it results that the cap covering the papilla, when seen in section longitudinal to the long axis of the tooth, seems to be formed by three principal layers. The uppermost is composed of a single row of cubical epithelium; the lowest layer consists of a single row of long cylindrical cells; the middle layer is formed of more or less compressed and branched epithelial cells, with a large amount of intercellular cement between them. They contain small oval or spherical nuclei, and, according to some authors, afford with the intercellular substance an example of mucous-tissue. Klein denies to this layer any other than an epithelial constitution.

It is the lowest layer of long columnar or prismatic epithelial cells which ultimately furnishes the enamel of the tooth. The two upper layers gradually diminish in thickness, and finally form a thin epithelial covering, which is found upon the surface of the enamel when the tooth first makes its appearance above the gum (*membrane of Nasmyth*).

At first the lower layer of enamel-cells is separated from the papilla by a thin elastic membrane, the remains of the basement-membrane upon which the epithelium of mucous surfaces is implanted. Later this disappears, when the enamel rests directly upon the dentine, which, as we shall see below, is formed by the papilla. It is still a mooted question whether the enamel of the tooth is secreted by the lower layer of columnar cells, or whether it is the product of a direct transformation of the cells themselves.

The *dentine* of the tooth is formed by the mediation of a double row of branched fusiform and columnar cells, which cover the pulp or papilla.

The *dental cement*, or bony incrustation of the dentine in the root and neck of the tooth, is developed from the fibrous tissue of the dental processes or alveoli. This tissue here has the structure and functions of the periosteum of bone.

STRUCTURE OF THE TEETH.

The fully-developed tooth consists of a crown, neck, and one or more roots, which like the long bones have a central marrow cavity. In this central cavity run the nerves and walls of the vessels.

Dentine.—Nearly the whole solid portion of the tooth is formed of a hard, compact, brittle substance called *dentine*. In the crown, the dentine is covered by a coating of *enamel*, the hardest substance met with in the human frame. In the neck and roots the dentine is incrusted by a shell of true bone of varying thickness. This incrustation of bone, technically

termed *cement*, is thickest at the deep end of the root. It gradually thins off toward the neck, until at this location it is lost in the enamel.

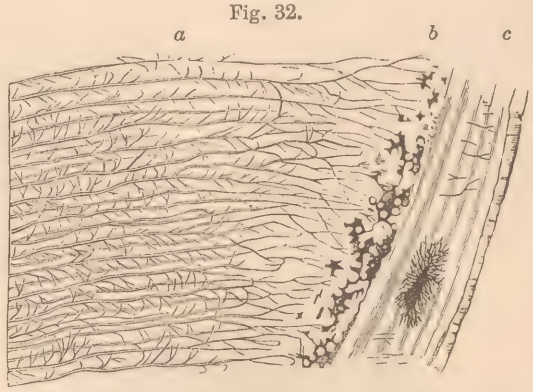
Dentinal pulp.—The *dentinal pulp* consists of an intricate reticulum of delicate branched connective-tissue corpuscles, with proportionally large and distinct round or oval double-contoured nucleus, and a small amount of cell-body, except that which constitutes the branched processes. Among these processes is a small number of lymphoid corpuscles and delicate connective-tissue fibres. The capillary bloodvessels have an investing cellular sheath just as in the fibrous form of mucous-tissue. Upon the external surface of the pulp is placed a double layer of branched columnar and fusiform cells, already alluded to. The cells nearest the pulp are more or less fusiform or stellate, with processes running into the pulp, and a few short lateral branches also, which connect one cell of the row with another. The outer ends of the cells of this row taper off into a fine long extremity, which passes between the cells of the outer row, and perhaps beyond them into the dentinal canals.

Odontoblasts, and dentinal fibres.—The outer row of columnar cells (so-called *odontoblasts*) is in contact with the dentine. These cells are more or less club-shaped, with the thick end of the club toward the pulp. The nucleus, which is usually somewhat oval in shape, is in this portion of the cell. The outer end of the club-shaped cell tapers off into a fine, long, somewhat tough, and apparently elastic process (*dentinal fibre of Tomes*). This long process of the odontoblast passes outward through the dentine, and in doing so frequently branches. The general course of the main fibres is straight or slightly wavy, and is perpendicular to the external surface of the dentine. By means of the lateral branches anastomoses are frequently formed with the processes of neighboring odontoblasts. According to most recent investigators, the dentinal fibre is surrounded by a thin structureless membrane, the *dentinal sheath of Neumann*. The interstitial substance between these dentinal sheaths, which latter constitute the dentinal canals, is a dense reticular substance made extremely hard and brittle by infiltration with the carbonates and phosphates of lime. When a thin plate of dentine is mounted dry the dentinal canals are filled with air, and when examined by transmitted light appear dark, like the canaliculi of bone-corpuscles similarly prepared. According to Klein, the dentinal fibres which lie in the dentinal canals are the processes of the inner row of the double layer of cells covering the pulp, and have no distinct connection with the outer row of odontoblasts. The same author thinks that those processes of the latter which enter the dentine, become calcified to form the interstitial substance between the dentinal canals. Nerve-fibres have been traced between the odontoblasts.

Interglobular spaces.—At the outer surface of the dentine the dentinal canals open into what are known as the interglobular spaces (*b*, Fig. 32).

These spaces are bounded on the side of the dentine by more or less globular projections of the ground-substance. They contain branched corpuscles, apparently similar in every respect to

Fig. 32.



SECTION THROUGH THE ROOT OF A MOLAR TOOTH.—*a*. Dentine traversed by its tubuli. *b*. Nodular layer. *c*. Cementum. (*Carpenter.*)

branched bone-cells. Their branches are continuous with the dentinal fibres, and with branches of cells in neighboring interglobular spaces. Where the dentine is covered with cement, these spaces communicate with adjacent bone-corpuscles, by means of the fine canaliculi of the latter. Beneath the enamel the interglobular spaces send a few short and irregular blind tubes among the deep ends of the enamel-prisms.

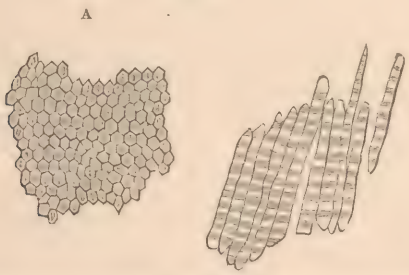
Cement (*cementum*).—The *cement*, or bony crust around the root of the tooth, presents the laminated ground-substance and the branching corpuscles of bone. Sharpey's fibres are present in small numbers. In the thickest portions, even Haversian systems with their small central canals are sometimes met with. Except in these rare instances of Haversian systems, the lamellæ are mainly found parallel to the surface of the root. The bone-corpuscles are sometimes unusually large; they possess numerous branched canaliculi, having the ordinary relations and structure of bone-corpuscles elsewhere, and they inclose typical bone-cells.

Enamel.—The *enamel* of the fully formed and healthy tooth is densely calcified. Seen under a high power, in a thin section vertical to the surface, the enamel appears to be formed of closely-

packed striæ, whose direction in general radiates from the pulp-cavity as a centre. In certain spots these radiating striæ are crossed by less distinct lines running mainly parallel to the surface of the enamel (transverse striæ). Besides these fine striations, there are often two, three, or more narrow, faint, darkish stripes (*parallel stripes of Retzius*) of considerable length; they exhibit a slightly undulating course, and, as a rule, run parallel to the enamel-surface.

The significance of these stripes is not fully understood. They may, perhaps, represent the division between successive deposits of enamel. The places at which transverse striæ are seen crossing the radiating striæ, contain enamel-fibres running in opposite directions. A minute description of the radiating striæ will suffice for both. They consist of long prisms or cylinders of calcified enamel-cells. When seen in transverse section these enamel-prisms appear more or less regularly hexagonal in outline (A, Fig. 33). In longitudinal section after maceration in hydrochloric acid, the enamel-prisms present the appearance represented in B, Fig. 33. At regular intervals the transparent hyaline-substance of the prism is seen to be crossed by extremely minute lines. A further maceration in the acid results in the breaking up of

Fig. 33.



Diagrammatic Representation of the Structure of Enamel.—A. Transverse section of enamel, showing the hexagonal form of its prisms. B. Separated prisms seen lengthwise. (*Carpenter.*)

the prism into as many somewhat cubical sections as there are areas occupied by these minute cross-lines. These prisms are separated from each other by a small amount of cement-substance. When the enamel begins to form, the enamel-cells lengthen towards the dentine. The lengthened portion soon becomes calcified, the calcareous deposit first appearing at the sides of the prism, or in the intercellular cement. After the calcification of the newly-formed end of the columnar enamel-cell has measurably progressed, the dentinal end of the cell again lengthens, and this new portion of the cell is in its turn calcified. This process repeats itself, until the original columnar enamel-cell is much lengthened, and the whole is gradually converted into successive sections of the enamel-prism. It is this successive periodic transformation of the enamel-cell into calcified prisms which gives to the latter the peculiar appearance shown in B, Fig. 33.

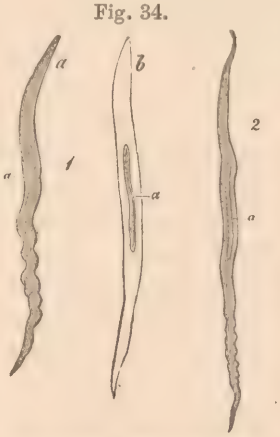
MUSCLE.

Muscular tissue comprises two general varieties, unstriped or smooth, and striated. The elements of this tissue are derived from the mesoblast, and are well supplied with capillary vessels and nerves.

SMOOTH OR UNSTRIPED MUSCLE.

This variety of muscular tissue is composed of spindle or fusiform cells, whose transverse diameter is usually small in proportion to the length of the long axis of the cell. These cells are soft, and are often more or less prismatic from mutual pressure. They may occur more or less isolated, but are usually collected into bundles. The cells constituting the bundles are closely packed together, the spindle extremity of one cell fitting between the bellies of two or more. These closely-packed muscle-cells are slightly separated from each other by a small amount of intercellular cement, apparently similar to that which unites the cells of epithelial surfaces. In this albuminous intercellular cement are often found a small number of flat, connective-tissue cells, more or less branched, and sometimes a very few scattered, delicate connective fibres. This intercellular material corresponds to the *endomysium* of striped muscles.

Fig. 34.



Smooth or Unstriped Muscular-Fibre-cells from Arteries [Human].—1. From the popliteal artery. A, without, B, with acetic acid. 2. From a branch of the anterior tibial; *a*, rod-shaped nuclei of the fibres. Magnified 350 diamters. (*Gray.*)

Arrangement and distribution of smooth muscle-fibres.—The muscular bundles thus composed are separated by a variable quantity of ordinary loose connective-tissue—an analogue of the *perimysium* surrounding bundles of striped muscles. The bundles of smooth muscles may anastomose with each other so as to form a regular muscular network. Such a muscular network may be spread out with a fenestrated layer. Frequently the bundles are placed side

by side to form continuous muscular membranes, or they may be collected into large bundles or cords. Besides the familiar locations in which smooth muscle-fibres are present, such as the muscular coat of the intestine, the walls of arteries, veins, and large lymphatic trunks, the iris and ciliary body, etc., they are also found around the ducts of glands and sometimes in the loose connective-tissue between their acini, in the infundibula of the lungs, in the fibrous trabeculæ of the spleen, sometimes in the trabeculæ of lymph-glands of the lower animals, and in many other places.

Form and minute structure of smooth muscle-fibres.—The spindle-cell of smooth muscle is sometimes branched at the extremity. The largest cells are found in the pregnant uterus near term, the smallest occur around the ducts of sweat-glands.

The minute structure of the smooth, fully-developed muscle-cell consists externally of a very delicate, scarcely visible, enveloping membrane, which seems to be of an elastic hyaline construction. Within this delicate membrane is inclosed the cell-body and nucleus. The body of the cell consists of a soft, gelatinous substance, in which are imbedded a number of fine fibrils. These fine fibrils run in the direction of the long axis of the cell, and when the element is seen longitudinally give it a delicate, longitudinal striation. The nucleus is generally more or less rod-shaped, and is located near the middle of the cell. It is limited by a thin envelope of double contour, and contains one or more small nucleoli. Within the nucleus is a close reticulum of fine fibrils, which, at the two extremities of the nucleus, are in connection with the fibrils of the cell-body.

Seen in transverse section, if the cut passes through at the level of the nucleus, the latter offers a circular outline near the centre of the cross-cut of the cell, which itself now appears more or less circular or polyhedral. In transverse section the cell-body appears dotted with fine points—the cross-cuts of the longitudinal fibrils above mentioned. Smooth muscle-fibres, when isolated and examined fresh, sometimes present little thickenings in their course, causing a slight moniliform outline of the element when seen longitudinally. These swellings are supposed to be due to irregular contractions of the substance of the fibre. Over the position of these slight swellings the thin enveloping membrane is often thrown into minute transverse folds or ridges. These occasional ridges of the membranous envelope of the smooth muscle-cell frequently give to the latter an apparent interrupted transverse striation.

STRIATED MUSCLE.

The voluntary muscles, namely, those which move the skeleton, the tongue, the pharynx, the upper part of the œsophagus, and some involuntary muscles, as for example the heart, and the diaphragm, are composed of muscular fibres, which, when fully formed, are striated, or striped. This form of muscular tissue is usually red or flesh color, while, on the contrary, the smooth muscular tissue is ordinarily quite pale.

Muscular bundles.—Striated muscles are composed of aggregations of very fine striated fibres, imbedded in a connective-tissue framework, which carries the necessary vessels and nerves. The muscle-fibres have certain relations to this connective-tissue framework, as well as to each other. The smallest striped muscles consist of a greater or lesser number of striated muscle-fibres (*primitive fibres*), running parallel to each other, and closely packed together to form a *primary bundle*. The *primitive fibres* during life are soft, and capable of assuming outlines due to mutual pressure. Between these more or less closely-packed primitive muscle-fibres, and separating as well as holding them together, is a certain amount of semi-fluid, albuminous cement-substance, in which are to be found a few delicate connective-tissue fibrils, and here and there a flat, perhaps branched, connective-tissue corpuscle (figs. 2, 3, Plate VI.). Occasionally in this interfibrous tissue we see also some large, granular plasmatic cells of Waldeyer, flattened between the primitive fibres. In this scant framework ramify small nerves and capillary vessels.

Endomysium and perimysium.—This delicate interfibrous tissue is known as the *endomysium*. It is in connection with the *perimysium*, a name reserved for the connective-tissue which surrounds the primary bundles. When several primary muscular bundles are bound together to form a larger muscle, we have a *secondary bundle* formed. In the perimysium or tissue surrounding the secondary bundles we have all the characteristics of loose connective-tissue. Even the presence of adipose vesicles may be noted, and arterioles and venules are quite frequent, as well as the corresponding lymphatics. In the larger muscles of the body, we meet with *tertiary muscle-bundles*, to form which a number of secondary bundles are bound together within a common sheath.

Muscle-fibres.—The *primitive muscle-fibre*, when not influenced by lateral pressure, is usually somewhat cylindrical in form. Its length is exceedingly great in comparison to the width of its cross-section. In small, short muscles, it is possible that

each primitive muscle-fibre may extend the whole length of the muscle. The longer and larger muscles are probably composed by many lengths of fibres whose ends overlap. It is believed by some authors that in such muscles no primitive fibre ever exceeds a length of one and a half or two inches. Near their extremities the muscle-fibres taper off to a more or less sharp conical point. The fibre is, therefore, somewhat spindle-shaped, and has a variable diameter according to the part selected. As in the fusiform smooth muscle-cells, the tapering extremity of one fibre is inserted between the thicker portions of two or more adjacent fibres. A cross-section of a muscular bundle composed of such an arrangement of primitive fibres will necessarily show fibres apparently of a widely varying diameter. While there are some actual variations in the size of the several primitive fibres which constitute a given muscular bundle, yet in a muscle which is not rapidly changing, the muscle-fibres have a very uniform diameter. The average diameter of striped muscle-fibres, however, not only differs enormously in different species of animals, but it also varies considerably between different muscles in the same animal.

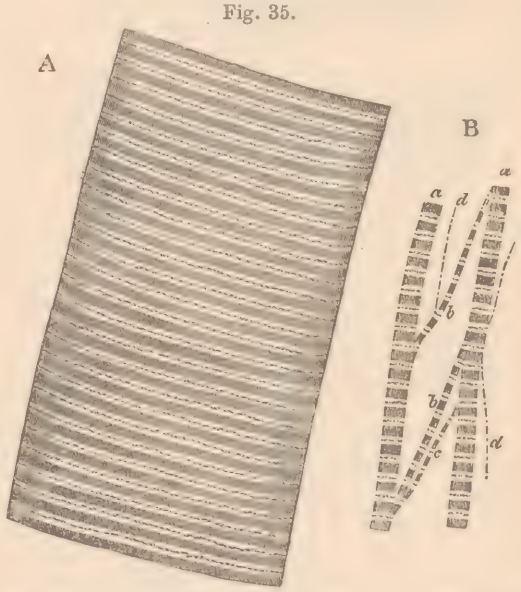
Form and structure of muscle-fibres.—The striped muscle-fibre is nearly always unbranched, but in human striated muscles we find some examples of branched fibres, as in the tongue, in some of the facial muscles, and in the heart. In the latter organ the branched fibres unite to form a genuine muscular reticulum. The peculiarities of the cardiac muscle will be considered later.

When a striped muscle-fibre is examined under the microscope during life, it is at first a gray and apparently nearly homogeneous cylinder. Soon after removal from the relations in which it naturally exists, it begins to show a faint segmentation into alternate dark and light cross-bands of unequal thickness. During a state of contraction of the fibre the dark bands are narrowest; in elongation of the fibre the dark bands reach their greatest width. The reverse is true of the light bands.

Contractile disks.—The action of hydrochloric acid upon the fibres causes them to be readily broken up into a countless number of thin transverse disks piled one upon another like rouleaux of coins. (See 3, fig. 1, Plate VI.) When the transverse marking into alternate bands of light and dark substance makes its appearance in fresh muscle, the fibres present the aspect shown in A, Fig. 35, when examined under a magnifying power of 700 or 800 diameters. The dark bands have been called *contractile disks*, the light bands *interstitial disks*.

Sarcous elements.—Sooner or later after the removal of the fibre from its normal surroundings the dark contractile disks begin to show extremely narrow light lines which run vertically and divide the tissue into a large number of short rod-like elements of a dark material. Under these conditions each disk appears to be constituted by a single row of alternating light and dark lines extending parallel to the axis of the muscle-fibre. The minute dark rods of which each contractile disk is composed are regarded as the ultimate contractile units, and are known as the *sarcous elements* of Bowman. They lengthen during elongation of the fibre, and shorten and increase in thickness during contraction. When the successive contractile disks of a muscle-fibre are differentiated into these alternate light and dark lines parallel to the axis of the fibre, the optical effect produced is that of a longitudinal striation, for the ends of the dark rods of one contractile disk are placed vertically above or below those of adjacent disks. Very frequently, indeed, the longitudinal and the transverse striations are simultaneously visible in the same fibre. Certain reagents have the effect of bringing out the one form of striation more distinctly than the other. Thus alcohol usually makes the longitudinal striation quite prominent, while on the contrary hydrochloric acid accentuates the transverse striæ.

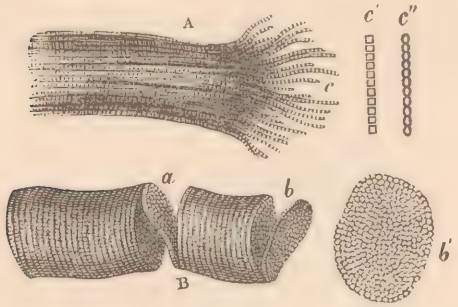
Fig. 35.



Striated Muscular fibre [Human].—A. Portion of a medium-sized muscular fibre, magnified nearly 800 diameters. B. Separated bundles of fibrils, equally magnified. *a a*, larger, and *b b*, smaller collections; *c*, still smaller; *d d*, the smallest which could be detached. (*Gray.*)

b', Fig. 36, gives a vertical view of a transverse disk after the latter has been differentiated into its ulti-

Fig. 36.

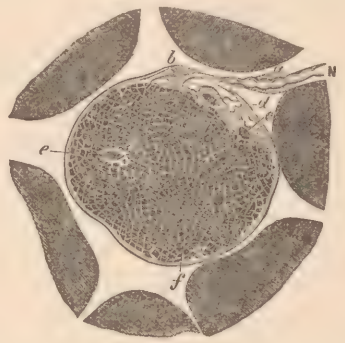


Fragments of Striped Elementary Fibres, showing a cleavage in opposite directions. High power. — A. Longitudinal cleavage. The longitudinal and transverse lines are both seen. Some longitudinal lines are darker and wider than the rest, and are not continuous from end to end. This results from partial separation of the fibrillæ. *c*. Fibrillæ separated from one another by violence at the broken end of the fibre, and marked by transverse lines. *c'*, *c''*. Two appearances commonly presented by the separated single fibrillæ more highly magnified. At *c'* the borders and transverse lines are all perfectly rectilinear, and the included spaces perfectly rectangular. At *c''* the borders are scalloped and the spaces bead-like. When most distinct and definite, the fibrilla presents the former of those appearances. B. Transverse cleavage. The longitudinal lines are scarcely visible. *a*. Incomplete fracture following the opposite surfaces of a disk, which latter stretches across the interval, and retains the two fragments in connection. The edge and surfaces of this disk are seen to be minutely granular, the granules corresponding in size to the thickness of the disk, and to the distance between the faint longitudinal lines. *b*. Another disk nearly detached. *b'*. Detached disk (more highly magnified), showing the sarcous elements. (*Gray*.)

mate sarcous elements, by the action of some reagent which has softened or dissolved the interstitial substance between them.

Fields of Cohnheim.—If a perfectly fresh and living muscle is frozen, and cut into thin transverse sections, and immediately examined under a high magnifying power, the following appearances are noted: At first the surface of the section is uniformly gray. Very soon the field begins to be mottled. The surface is now everywhere marked by fine brilliant lines which cross each other in such a manner as to form an irregular bright network inclosing darkish-gray areas. The dark-gray areas are the ends of the ultimate sarcous elements or the dark rods seen as above stated when the longitudinal fibrillation becomes apparent. The light lines correspond to sections of the bright substance between the dark rods. The width of the bright lines mottling the gray field gradually increases a little during the observation, while at the same time the dark areas limited by the meshes correspondingly lessen in extent. The dark areas are the so-called *fields of Cohnheim*. The central object in Fig. 37 very well represents the appearance above described, although it was intended merely to show the manner of termination of a nerve. The dark areas or fields of Cohnheim are dotted with extremely fine points. These are the ends of fine fibrils which can be observed in the sarcous elements when the latter are seen longitudinally under favorable conditions. Various reagents which effect the

Fig. 37.



Transverse Section of one of the Muscles of the Thigh of the Lacerta agilis (a common European Lizard), made whilst frozen, and magnified 400 diameters.—N. Nerve of a muscle-fibre which is surrounded by portions of six others. *a*. Nucleus of the nerve-sheath. *b*. Nucleus of the sarcolemma. *c*. Section of nucleus of terminal plate of nerve. *d*. Transverse section of terminal plate, surrounded by granular material. *e*. Transverse section of muscle-nuclei. *f*. Fine fat-drops. The angular dark particles are sections of groups of sarcous elements. (*Carpenter*.)

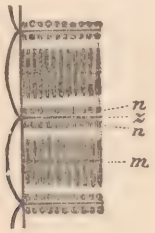
death of the constituents of the muscle-fibre cause the sarcous elements to shrink from each other and leave proportionately large spaces between them, which are filled with an interstitial cement-substance —the light network seen in transverse sections, and the light lines observed between the rod-shaped sarcous elements when the fibre is viewed lengthwise.

Sarcolemma, intermediate disks, etc.—The muscle-fibre is more or less closely enveloped in a thin, tough, elastic, apparently hyaline sheath—the *sarcolemma*. This elastic tube is partitioned across at short, regular intervals by thin plates which are offshoots from the inner wall of the sarcolemma. Such plates consist of substance somewhat similar to that of the sarcolemma, but are not so tough and resistant. They cross the tube through the middle of the light or interstitial disk, and are known as the membranes or *intermediate disks of Krause* (*z*, Fig. 38).

The intermediate disks of Krause, therefore, divide the tube formed by the sarcolemma into cylindrical sections, placed end to end. Each of these cylindrical sections contains a dark contractile disk, with a half of an interstitial disk above and below, separating it from the intermediate disks of Krause. In each half of the light interstitial disk is frequently found a thin transverse layer of somewhat dark substance which separates into granules when the dark contractile disk shows a division into sarcous elements. This thin layer of dark substance has been

called the *secondary* or *collateral disk* (*n*, Fig. 38). It requires strong and well-defining lenses for the demonstration of these details of the structure of muscle-

Fig. 38.



STRUCTURE OF STRIATED MUSCULAR FIBRE, AFTER ENGELMANN, FROM TELEPHORUS MELANURUS (A COMMON EUROPEAN BEETLE). CUTANEOUS MUSCLE FROM THE ABDOMEN.—*m*. Median disk. *n*. Secondary disk. *z*. Intermediate disk. Magnified 1000 diameters. The sarcolemma is seen on the left side.

fibres. Engelmann and Hensenn have each recorded the presence, in the middle of the transverse or contractile disk, of a transverse, lighter band which they have called the *median disk* (diagrammatically shown at *m*, Fig. 38). The above-described dark elements of the striped muscle have been found to be doubly refracting; they consequently polarize light, while the light substance which separates them has not a similar effect upon the luminous rays.

The shortening and transverse thickening of the dark rods or sarcous elements of the contractile disk, which takes place during contraction of the fibre, causes the interstitial substance to apparently increase in amount. Since the thickened rods are then more closely pressed together, the fluid portion of the interstitial substance must necessarily be squeezed out above and below, and increase the volume of the half of the light or interstitial disk above and below the contractile disk. Frequently a part of this expressed interstitial substance finds its way between the sarcolemma and the edge of the contractile disk, and separates the two, thus producing a convexity or bulging of the sarcolemma at these points. This condition is shown somewhat diagrammatically on the left in Fig. 38. Sometimes the attachment of the intermediate disk of Krause to the sarcolemma breaks, either from a destructive process at work in the fibre itself, or from the action of reagents which soften the intermediate disk and cause the substance of the light interstitial disk to swell greatly. The sarcolemma may then be separated from the surface of the muscle-fibre for a considerable part or the whole of its length. Occasionally the muscle-fibre may suffer a transverse fracture within the sarcolemma. A retraction of each fragment then takes place, resulting in their separation. Such a condition is shown in 1, fig. 1, Plate VI. The ensheathing sarcolemma remaining unbroken becomes wrinkled, and perhaps twisted, as is seen at *n*, 1, in the figure last mentioned. These fractures invariably pass through the light or interstitial disk.

The interstitial substance between the sarcous elements often contains, especially in the lower animals, minute molecules, sometimes of pigment, sometimes of fat—the *interstitial granules* of Kölliker.

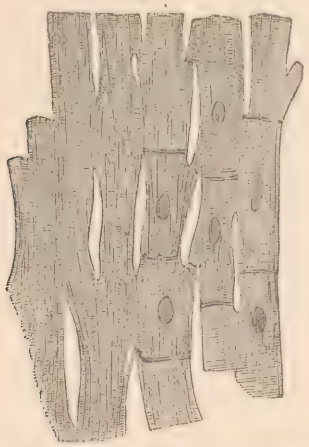
Muscle-corpuscles.—Besides the constituents above enumerated, striped muscle-fibres contain, at more or less scattered intervals, cellular elements which appear to be closely analogous to connective-tissue corpuscles. In nearly all the muscles of most of the higher animals, these elements rest upon the surface of the muscle-fibre, and form a part of it. They are not connected with the sarcolemma. In some of the Amphibia, these cells are scattered through the substance of the fibre (see *e*, Fig. 37). In birds they are found in both locations. In the muscle of the heart of man they exist near the centre of the fibre. When in the depth of the fibre, they are imbedded in the interstitial substance, and they consist of a flattened oval nucleus, containing one or more nucleoli, the long axis running parallel with the length of the fibre. In the adult, fully-matured, normal muscle-fibre, the nucleus is surrounded by a very small amount of protoplasm, which is more extensive at the ends of the oval nucleus, where it is frequently lengthened out into a tapering extremity. The broad surface of the cell then presents a somewhat fusiform outline. When seen in profile the outline appears more linear. The protoplasm usually contains a certain number of dark, or, sometimes, shining granules, mostly aggregated at the poles of the cell.

These cells are known as *muscle-corpuscles*. Their office has been variously interpreted. Some have thought them to be the terminal organs of the nerves, which supply the fibre. Others have regarded them as simple connective-tissue corpuscles. The weight of opinion, however, seems to support the view that they are the builders of the muscle-fibres. The relation which they bear to the growth of muscle will be considered when we speak of its development.

Cardiac muscle-fibres.—In the heart of man the muscle-fibres possess certain peculiarities. In the first place they seem to be destitute of an investing sarcolemma. In the second place they are very short, and are branched in the manner shown in Fig. 39. Each fibre possesses one or more nuclei, which are imbedded in the depth of the fibre. The end of a branch of one fibre abuts against the end of that

of another. In this way an anastomosis of the branched muscle-fibres is formed. When heart-

Fig. 39.



Anastomosing Muscle-Fibres of the Heart, seen in a longitudinal section. On the right the limits of the separate cells with their nuclei are exhibited somewhat diagrammatically. (*Gray.*)

muscle is cut transverse to the direction of the muscle-fibres, instead of the cross-section of the fibre presenting a circular outline, as in ordinary striped muscle, it is often elongated. This is the case when the cut has passed through the body of the fibre near the point where it branches. Because of the extreme shortness of the branched muscle-fibres almost every one of them in the cross-section is seen to contain near its centre a muscle-corpuscle.

Termination of muscle-fibres.—As has already been mentioned, each individual muscle-fibre terminates in a tapering conical extremity. Whether these extremities end in tendon, or in the depth or body of the muscle, in the endomysium between the muscle-fibres of the primary bundles, they are attached to connective-tissue fibres (*t*, 2, fig. 1, Plate VI.). It seems to be still unsettled exactly how this connection is established.

Unless the tissue is especially prepared for examination, the longitudinal fibrillæ appear to be directly continuous at their extremity with the connective-fibres, and the one seems to pass insensibly into the other. Perhaps such a simple connection may really exist in many instances; but it is probable that, in most cases, where muscle is inserted into tendon, there is a different mode of communication. The sarcolemma probably continues without interruption around the conical end of the muscle-fibre, and at this point is attached by its external surface to the bundles of fibrous tissue which form the tendon. Whether the

EXPLANATION OF PLATE VI.

Fig. 1. The appearances of striated muscle-fibres after varied treatment. Moderate power. (Frey.)

1. A muscle-fibre (*m*) ruptured at *n*, showing the sheath or sarcolemma partly emptied and twisted.

2. The end of a muscle-fibre from the biceps of Man, *m*; a fibrous bundle, *t*, of the interstitial connective-tissue is attached to its pointed extremity.

3. A Human muscle-fibre after prolonged treatment with hydrochloric acid. It can now be readily split up into transverse disks. *n*, nucleus of muscle-corpuscles.

4. A muscle-fibre from the leg of a Frog after protracted treatment with dilute hydrochloric acid. From the cut end, *t*, very fine fibres, upon which minute granules are distributed, are seen projecting.

Fig. 2. Transverse section of Human biceps. High power. (After Frey.)

m, Muscle-fibres, cut across; *v*, a section of a bloodvessel; *c*, a fat vesicle in the interstitial connective-tissue.

Fig. 3. Fragment of sartorius muscle of a Frog. High power. (After Ranvier.)

n, Nuclei of muscle-corpuscles, seen partly in face.

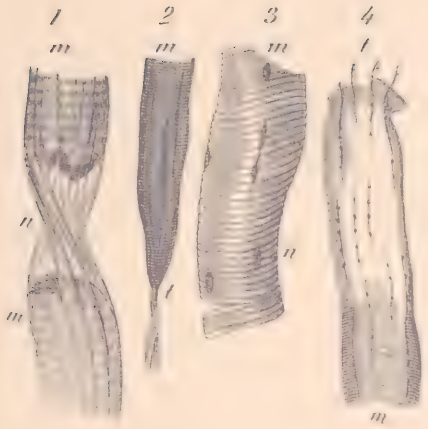
Fig. 4. Muscle-bundle of the dorsal fin of the *Hippocampus* (a fish commonly known as the sea-horse), showing method of attachment of the fibrous bundle of the tendon. High power. (After Ranvier.)

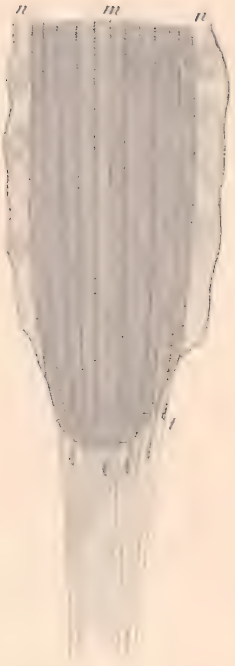
m, Muscle-fibres; at *t* they are attached to the tendon-fibres through the intermediation of a double-contoured membrane, which is continuous with the elastic sheath (*n*) of the bundle.

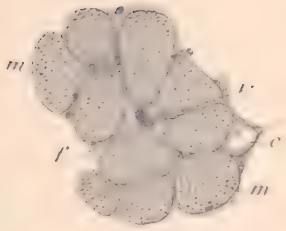
Fig. 5. Highly-magnified capillary bloodvessel, after injection with a weak solution of nitrate of silver, and subsequent staining with picrocarminate of ammonia. The dark lines mark out the boundaries of the endothelial cells forming the wall of the vessel; the nuclei are also distinctly seen. (Ranvier.)

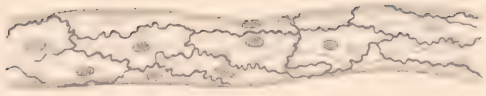
Fig. 6. Shows a capillary bloodvessel, surrounded by and attached to the fibres of the reticular tissue. (Ranvier.)

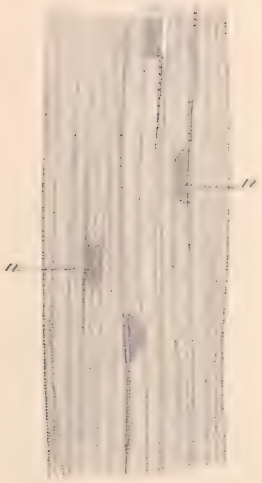
c, The capillary; *r*, the reticular fibres; *n*, nuclei of flat endothelial cells upon the reticular fibres.













T. Sinclair & Son, lith.

fibres of the tendon are inserted into the sarcolemma at this point, or are simply glued upon its exterior surface by the intervention of a tough, sticky material, has not yet been determined. Fig. 4, Plate VI., represents such a mode of insertion of a muscle-fibre into tendon. The preparation from which the drawing was made is from the large dorsal fin of the *Hippocampus*, or sea-horse. But the artist has failed to show distinctly the most important feature of the preparation. At *t*, where the muscle-fibre ends in the tendon, the line between the two should have a double contour, and be continuous with the double-contoured line representing the sarcolemma ensheathing the muscle-fibre.

DEVELOPMENT OF MUSCLE.

Muscular tissue is developed from the cells of the middle or connective-tissue layer of the blastoderm. The fibres of striped muscles originate in the following manner: A fusiform cell in the connective- or gelatinous tissue of the embryo suffers a division of its nucleus. The two new nuclei divide again, and this process continues until the original uni-nucleated spindle-cell has become more or less completely filled with a number of nuclei arranged in a linear series from one end of the cell to the other. Proceeding equally with this increase of nuclei, the cell thickens somewhat, and greatly elongates. Here and there the cell-body soon begins to show cross-markings—the earliest appearance of the transverse disks. This transformation of the cellular protoplasm into the contractile elements of the full-grown muscle continues to spread throughout the fusiform cell-body, until nearly the whole of the latter becomes transversely striated. The protoplasm immediately surrounding the nucleus is the last to experience this metamorphosis.

Even in the full-grown and adult fibre a small portion of the original protoplasm remains around the nucleus, and constitutes, with the latter, the muscle-corpuscle above described. It is not yet known whether the sarcolemma is the product of an excretion by the protoplasm of the muscle-cell, or whether it is a formation from the surrounding connective-tissue.

Reproduction of muscle-fibres.—In various muscles of the human organism are many striped fibres containing a very large number of muscle-corpuscles, surrounded by a proportionately large quantity of protoplasm, and presenting other evidences of growth. It is probable that in health there is a continual destruction and reproduction of muscle-fibres. It is certainly so in many diseases.

BLOODVESSELS.

The blood of man flows throughout the body in a system of channels, which, according to their size, construction, and the character of the blood passing through them, are denominated arteries, veins, capillaries, sinuses.

Each of these species of bloodvessels has a characteristic structure which generally differentiates it from all the others. But while there is a general plan of construction common to the members of each species, there are slight differences which constitute varieties. Some of these variations will be incidentally noted.

Capillaries. — The simplest form of bloodvessel met with in man is the blood-capillary — an extremely minute tube. The most primitive form of the capillary is that of a simple cylindrical channel hollowed out in the connective-tissue, with no other definite wall than that of a delicate, elastic, limiting membrane, consisting of a single complete layer of flat, thin, elastic, endothelial plates, such as have already been described as covering serous surfaces. Each of these endothelial plates contains one, sometimes two, flattened ovoid nuclei. Under favorable conditions intra-nuclear and intra-cellular networks can be demonstrated in these cells. Staining by nitrate of silver and exposure to light blackens the intercellular cement between their edges, which are normally in apposition with edges of the adjacent endothelia, and if the preparation is subsequently stained with carmine the nuclei show a brilliant red. The capillary, of which fig. 5, Plate VI., is a very faithful drawing, has been treated in this manner. The outlines of the cells are shown deep black upon the top of the capillary cylinder, and by dotted lines on the bottom portion. The cells are seen to be more or less lozenge-shaped, with the long axis of the cell running with the length of the capillary. The edges of cells are observed to be sinuous. The sinuosity of the edges of the cells is much lessened when the capillaries are distended. Under the influence of irritation or inflammation the endothelia swell up. Their edges then become separated at points, thus forming openings in the capillary wall. The smallest of these are called *stigmata*, the largest *stomata*. Probably it is through these openings that the elements of the blood escape during inflammation. According to some authors, they are in direct communication with the lymph-spaces of the surrounding connective-tissue.

A little more complex form of the blood-capillary consists of an addition to the vessel of an incomplete sheath of fusiform or stellate connective-tissue cells, whose branches form a network. These cells float in a thin lymph-space, which in part surrounds the vessel, and the two together constitute a delicate outer or *adventitious coat* (*tunica adventitia*). In some locations the capillaries are completely invested by a cylindrical lymph-channel, in which case the walls of the channel are lined with endothelium, and the exterior surfaces of the capillaries are also covered by similar cells. This is usually the character of the capillaries of the brain and spinal cord.

When capillaries run through reticular tissue their walls are connected with the branches of the reticulum (fig. 6, Plate VI.).

The capillaries vary greatly in size in different locations. In the cerebro-spinal nervous system and in the lungs they are smallest, in the marrow of bone they are largest.

Moreover, in some locations, they are quite irregular in calibre. In the inner layer of the dura mater, and in the interstitial connective-tissue of many muscles, they sometimes present varicosities or even diverticula of odd forms.

Many authors have claimed for the capillaries a moderate contractile power, through the agency of which their calibre may be more or less modified.

Arteries.—The simplest structure of the artery is found in the smallest vessels of this class. Such vessels are known as *arterioles*. The capillaries pass so gradually into the arterioles that it is often difficult to say exactly where the one begins and the other ends. The wall of each arteriole has a much greater thickness than that of the capillary in which it ends, and is more complex in its structure. Next to the blood-stream lies the same endothelial layer as is found in the capillaries. It has also an adventitious coat externally, which is a further development of the delicate tunica adventitia surrounding many capillaries. Between these two inner and outer coats of the arteriole is a third or middle muscular coat. The distinctive feature of the arteriole is the existence of this muscular tissue in the middle coat of the vessel. The muscle-fibres are short, smooth, and spindle-form, and run around the inner coat in a transverse direction.

In that part of the arteriole nearest the capillary, these transversely arranged smooth muscle-fibres do not form a continuous layer. The cells are usually a little too short to completely encircle the vessel. At intervals, two or three are grouped together on one side of the arteriole, while the opposite side remains uncovered. By means of an alternation of these groups of cells around opposite sides of the vessel, the arteriole is practically supplied with the means of narrowing and widening its lumen. A little nearer the heart the layer of muscle-fibres

Fig. 40.



Cerebral Arterioles (Human).—1. Smallest artery. 2. Transition vessel. 3. Coarser capillaries. 4. Finer capillaries. *a*. Structureless membrane still with some nuclei, representative of the adventitious coat. *b*. Nuclei of the muscle-fibre-cells. *c*. Nuclei within the small artery, perhaps appertaining to the endothelium. *d*. Nuclei in the transition vessels. Highly magnified. (*Gray.*)

forms a continuous uninterrupted membrane. The wall of the smallest artery may then be regarded as composed of three coats or tunics—the *external coat* or tunica adventitia, the *middle* (*muscular*) *coat* or tunica media, and the *inner coat* or tunica intima. The tunica adventitia of the larger arterioles still represents the tunica adventitia or lymph-sheath of the capillaries above described. There is a network of branched corpuscles which lie in lymph-spaces formed by a loose reticulum and felt-work of white fibrous tissue. Between the tunica adventitia and the tunica media in the larger vessels of this class there are frequently found a few fine elastic fibres collected into a network. Between the tunica media and the tunica intima in these vessels is also a small number of elastic fibres, the elastic layer of the tunica intima. Between such a delicate elastic layer and the endothelia lining the tunica intima exist, even in arteries of this size, a small number of branched connective-tissue cells connected together into a membranous network.

In *arteries of a larger calibre*, the various elements

entering into the construction of the different arterial tunics are more fully developed, while a few other characteristics are added. The tunica adventitia has gained in thickness by a more complete development of a connective felt-work, whose fibres now have a prevalent longitudinal course. Scattered among these bundles of white fibrous tissue appear a few fine elastic fibres. In the loose meshes formed by the intercrossing of the fibrous bundles are more or less numerous connective-tissue corpuscles and lymphoid cells. These loose meshes thus formed are lymph-spaces, which very freely intercommunicate.

The elastic fibres become more abundant and larger as the tunica media is approached. At the line of union between the outer and middle coats, the elastic fibres form a dense network, and spread out more or less into a fenestrated membrane which constitutes the line of division between these two tunics. This dense collection of elastic fibres has been termed the *external elastic* membrane.

The tunica media is now constituted by a much more numerous collection of smooth muscle-fibres; but, instead of forming as before a continuous muscular membrane composed of a single layer of cells, the latter are arranged in several more or less continuous layers, the cells of each layer, however, still running transversely around the axis of the vessel. The several muscular layers of which the tunica media is now composed are separated from each other by plates of elastic tissue in the form of fenestrated membranes. These elastic plates run mainly longitudinally and at the same time parallel to the curved surface of the vessel. They are connected with those internal and external to them by means of networks of fine elastic fibres (fig. 3, Plate III.) which run among the cells of the muscle-layers. Between the muscular membranes which the last-named cells constitute, is also to be found now for the first time a very small amount of fibrous connective-tissue with elements which usually accompany it.

At the external boundary of the tunica intima, and forming a sharp, distinct line of division between it and the media tunica, is another dense accumulation of elastic tissue—called the *internal elastic membrane.* It consists, in small arteries, of two or more fenestrated elastic layers so closely packed against each other as to present in section an appearance of a simple structureless elastic membrane. Internal to this elastic layer of the tunica intima is a slight accumulation of delicate white fibrous tissue. The direction of these fibres is mainly longitudinal. They intercross, however, at acute angles, and form between them lymph-spaces elongated with the axis of the vessel. These spaces contain fusiform and branched connective-tissue corpuscles, as well as an occasional lymphoid cell. This connective layer is covered internally by the endothelia lining the lumen of the vessel. The outline of these cell-plates is that of a sharp-pointed lozenge, and their edges are somewhat sinuous. When the artery is cut transversely, the internal elastic layer of the tunica intima is shown beautifully festooned—an appearance which gives the inner surface of the arterial wall an extremely wavy outline. Seen in face, the inner surface of the artery appears covered with longitudinal folds or ridges.

In the large arterial trunks, the tunica media and intima become much thicker. In the tunica media, the number of muscular layers is much increased, as well as are the thickness and size of the elastic plates between them. The elastic fibres which form a network among the muscle-cells are also much stouter than before. Instead of nearly all the muscle-fibres running transversely, as in the smaller vessels, there are to be found in some arteries longitudinal and oblique bundles, especially in the inner portion of the tunica media. These are occasionally met with in the tunica adventitia, but rarely in the longitudinal fibrous layer of the tunica intima.

The elastic layer of the tunica intima is much thicker, and is also laminated. Between the laminæ is to be found a small amount of connective-tissue. The layer of longitudinal fibrous bundles beneath the endothelial lining of the lumen of the vessel is now quite distinct.

As a rule, the larger the artery the thicker becomes the muscular tunic and the more numerous the muscle-fibres. In the aorta, however, we have a partial exception to this rule (fig. 1, Plate VII.). Of this great vessel the following characteristics may be enumerated. The tunica adventitia is here comparatively thin. The tunica media is thick, but the layers of muscular tissue are thin, and the muscle-fibres which constitute them are scattering. In the inner portion of the tunica media the elastic plates which separate the muscular layers are also thickened and laminated. The fibres of the elastic network which unite the plates and which anastomose among the muscle-fibres are thick, tough, elastic cylinders, whose main direction is longitudinal to the axis of the vessel. In the outer portion of the tunica media the elastic plates are less laminated and are not so thick as in smaller arteries; neither are the elastic fibres so large. An appreciable amount of connective-tissue is scattered through the middle coat. The tunica intima is

thicker, but does not otherwise differ from that of other large arteries.

The muscle-fibres of the arteries are in the main simple, smooth, fusiform cells with rod-shaped nuclei. In the larger trunks the ends may be more or less bifurcated or even branched. In the aorta, flattened, stellate muscle-cells are often met with.

The walls of the arteries are relatively thick, and, owing to the large amount of elastic tissue composing them, the lumen is usually patulous. The thickness of the arterial wall varies considerably, according to whether the vessel is distended or not. In the large vessels the outer and middle coats are supplied with bloodvessels—the *vasa vasorum*. In a few instances, capillary vessels even enter the tunica intima.

Veins.—The veins differ considerably from the arteries. In the first place, the lumen of the vein is usually considerably larger than in the artery of the same grade, yet the wall of the vein is much the thinner. There are differences also in the minute structure. The smallest vessels which collect the blood from the capillaries are known as *venules*. Their walls are extremely thin, yet they can be readily differentiated, as with the arteries, into three coats—the external or *tunica adventitia*, the middle or *tunica media*, and the internal or *tunica intima*. The tunica adventitia consists of a simple network of fusiform or stellate cells floating in a narrow lymph-channel. The tunica media is composed of simple connective-tissue scarcely differentiated. It contains as yet no muscle-elements. The tunica intima is very thin, and is separated into thin layers which closely correspond to those of the tunica intima of arterioles. The outer layer consists of a delicate fibrous membrane with the fibres running longitudinally. The middle layer is represented by a few stellate cells with their branches anastomosing. Resting upon these stellate cells is the inner layer composed of thin endothelial cell-plates similar to those of the arteries in all except outline. They are much broader and shorter than are the same cells of the arteries, and have rather more sinuous outlines. *Stigmata* and *stomata* are formed here as in the capillaries, and there may be consequently out-wandering of the blood-cells.

In veins of a little larger calibre, the tunica adventitia increases in thickness and strength by an accession of fibrous bundles, which have a prevalent longitudinal direction, but which branch and interlace in such manner as to form a loose meshwork in which lie branched connective-tissue corpuscles, and a few lymphoid elements. At the junction of the tunica adventitia with the tunica media the connective-tissue bundles are aggregated so as to form a more or less distinct fibrous membrane, corresponding in position to the external elastic membrane of the arteries. In most veins of this size the tunica media contains, in addition to the elements of loose connective-tissue, a few scattered, smooth muscle-fibres ar-

EXPLANATION OF PLATE VII.

Fig. 1. Longitudinal section of thoracic aorta of Man. High power. (After Ranvier.)

The central part of the middle coat is not drawn.

1. Internal layer of the internal coat, or tunica intima.
2. External layer of the internal coat.
3. Elastic lamina dividing the internal and middle tunics of the artery.
4, 5. Smooth muscular fibres of the middle coat, cut transversely; among them are elastic fibres and elastic plates.
6. External coat.

Fig. 2. Showing development of capillary bloodvessels in the normal omentum of a Rabbit. High power. (After Klein.)

a, Capillary bloodvessels; *b*, connection of the capillaries with branched cells of the extravascular tissue. It is by metamorphosis of these branched cells that new vessels are formed.

Fig. 3. Shows an artificial injection of the blood and lymph-vessels of the parietal peritoneum. Medium enlargement.

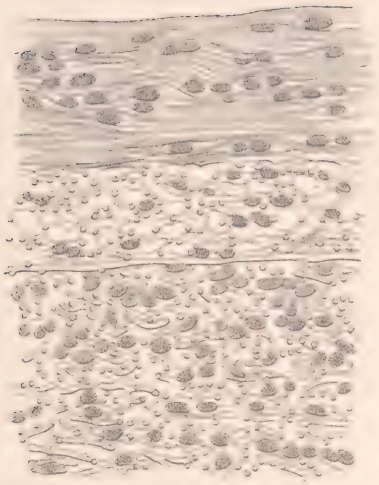
l, Network of lymph-trunks; *v*, venules and arterioles; *c*, capillary bloodvessels.

Fig. 4. *A*. Shows, under a moderate power, an injection of the capillary network in the walls of the alveoli of an inflated lung. The vessels were filled from the pulmonary artery.

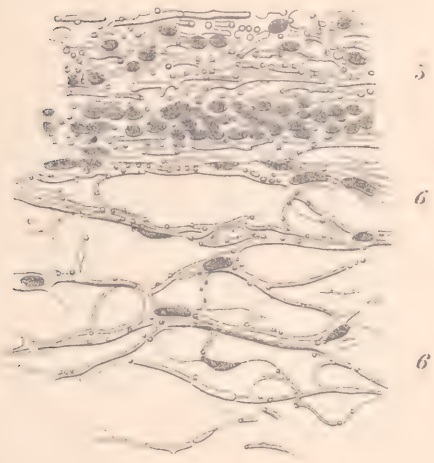
B. An injection of the pulmonary blood-capillaries (*b*) in the lung of a human fœtus—the air-vesicles (*a*) never having been inflated.

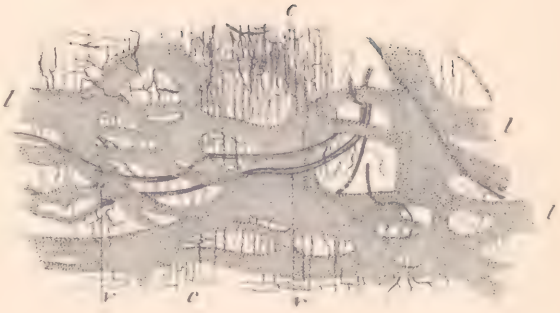
Fig. 5. Shows a silver injection of the bloodvessels of the lung of a Frog. High power.

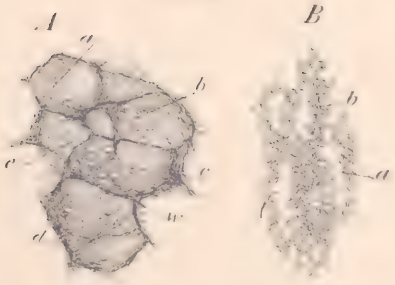
v, Larger vessel; *v'*, small arteriole which distributes its blood to capillaries (*c*) in the walls of the air-vesicles; *a*, inter-capillary areas.

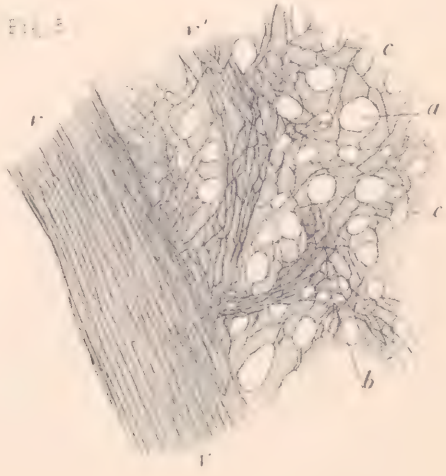












T. Sinclair & Son. Lith.

ranged transversely. The tunica intima is extremely thin, and presents the same structure as in the venules.

In the *larger venous trunks* the structure of the vessel is essentially the same as that of the vessels last described. The tunica adventitia is strengthened by the presence of a greater quantity of connective-tissue fibres. The tunica media in most cases contains a number of muscle-layers with the cells, for the most part running transversely; elastic tissue is, however, entirely absent. The layers of muscle-cells are separated by lamellæ of fibrous tissue whose individual bundles pursue a general longitudinal course. The outer layer of the tunica intima consists of a dense fibrous membrane, sometimes laminated. The subendothelial layer contains longitudinal fibrous bundles, in the interspaces of which are stellate and lymphoid cells. The endothelial lining is not different from that of the smaller veins.

In many veins, the tunica media possesses no muscle-fibres. The veins of bone, of muscle, of the retina, of the membranes of the brain and spinal cord, the cardiac ends of venous trunks emptying into the superior vena cava have no muscles. Some veins possess only a longitudinal muscular coat, as the veins of the pregnant uterus. Others possess an outer longitudinal and inner circular layer of muscle-fibres.

In some veins, the distribution of the muscle-fibres is not limited to the middle coat. They are not infrequently found in the tunica adventitia, and are occasionally present even in the tunica intima.

The foregoing division of the walls of veins into three distinct coats as in the arteries is not accepted by all investigators. Ranvier thinks that the walls of these vessels should be regarded as consisting of only two tunics, an inner and an outer. According to him, it is in the innermost portion of the latter that muscle-fibres are usually located, but they may at times be found throughout the greater part of its thickness.

Nearly all the veins are furnished with *valves* for the purpose of preventing a backward flow of the blood. At the location of the valves, there is a slight ampullar enlargement of the calibre of the vein, a provision which prevents a serious encroachment upon the diameter of the blood-channel when the valves are open and their leaflets flattened against the walls of the vessel. The following peculiarities in the structure of the valves may be adverted to here: Each surface is covered with a single layer of endothelial plates. Upon the inner surface the endothelia are entirely similar to those lining the vein, *i. e.*, more or less lozenge-shaped, with the long axis parallel to the axis of the vein. Upon the outer surface, however, the long axis of the endothelial plates is, in the main, transverse to the axis of the bloodvessel. Immediately beneath the endothelium is a subendothelial layer of connective-tissue fibres interspersed with a few elastic fibres. This layer is thicker and much more abundant in elastic fibres upon the inner than upon the outer surface of the valve. Between and upon these fibres connective-tissue cells, both fixed and wandering, are present in variable number. The subendothelial layers of the two surfaces of the valve are separated from each other by a thin, tough, fibrous membrane composed of interlacing white fibrous bundles whose general direction is parallel to the edge of the valve. Some elastic fibres are also scattered among the white fibrous bundles, and according to the statements of some authors a few muscle-fibres may be found near the base of the valve. When muscle-fibres are present, the direction of their long axis is usually transverse to the axis of the vessel. The endothelium and the subendothelial layer, lining the ampullar enlargement of the vein at the location of the valves, are similar to those which cover the outer surface of leaflets of the valve.

Sinuses.—Custom among anatomists has fixed upon the term sinus a double and somewhat indefinite significance. Many vessels of the human economy which have received this name possess no circumstance which distinguishes them from veins, other than the simple fact that they constitute various channels in fibrous membranes, *e. g.*, some of the cerebral sinuses. Most, if not indeed all, of the sinuses of the blood-vascular system may be justly regarded as varieties of veins, for their blood is that of the venous system, and so also in many respects is their histology.

The cavernous sinus, and the cavernous tissue of the corpus cavernosum of the penis, present two distinct types of genuine sinuses.

In the former we have a vein whose calibre is broken up into reticulæ of various sizes and shapes by fibrous trabeculæ springing from the walls of the sinus, and extending across the lumen of the vessel. The fibrous bundles are continuous with the middle tunic of the vessel, and contain such elements as are present in that coat. The trabeculæ are covered by endothelial-cells and a subendothelial tissue similar to those of the walls of the sinus. They sometimes inclose small bloodvessels.

The corpus cavernosum of the penis presents a somewhat different construction. As its name implies, it is a cavernous tissue. It consists essentially

of a reticulum of interlacing bands, or trabeculæ of smooth muscle-fibres, associated with a variable amount of elastic fibres and bundles of white fibrous tissue. The spaces formed by the interlacement of these trabeculæ are of variable size and outline, and they freely intercommunicate. The surfaces of the trabeculæ are covered with a layer of endothelial cells and a subendothelial tissue very similar to those of large veins. The trabeculæ contain arterioles which distribute their blood to a plexus of capillary vessels which also are contained within the trabeculæ. Most of these capillaries empty into the cavernæ formed by the interlacing trabeculæ. The blood of these sinuses or cavernæ is collected by venous trunks, and the communicating cavernæ may consequently be regarded as a complicated venous sinus.

Development of bloodvessels.—The earliest form of the complete bloodvessel is the capillary. By the successive addition of the elements which constitute their distinctive features, arteries and veins are formed from vessels which were originally in the condition of capillaries. These minute blood-channels frequently give origin to new capillaries in the following manner:—

In young, growing connective-tissue the walls of the simplest form of capillary, above described, here and there give off solid protoplasmic projections, which may be more or less branched, and which are frequently irregular in outline (fig. 2, Plate VII.). The nuclei contained in these solid protoplasmic cylinders divide and increase in number. The portion in connection with the previously-formed capillary becomes hollowed out and filled with blood from the open lumen of the vessel. In the portion more remote from the capillary, vacuoles appear at intervals in the protoplasmic cylinder. These soon open into one another, and constitute a channel in the protoplasmic branch. By an extension of this process of vacuolation a hollow tube is produced, the lumen of which freely communicates with the lumen of the original capillary. As this process of vacuolation proceeds, the nuclei are pushed to the side of the protoplasmic cylinder, where they remain to form the nuclei of the future endothelium. The calibre of the new capillary ultimately becomes regular in outline, and what remains of the original protoplasm of the tube divides into endothelial plates and their intercellular cement.

Instead of the formation of a new capillary loop by vacuolation of a protoplasmic projection from the wall of a capillary, a connective-tissue corpuscle, which by one of its branches is connected with the wall of a capillary, may swell up, experience division of its nucleus, enlargement of its branches, and through the same process of vacuolation be converted into a young capillary.

This process of vacuolation may even affect con-

EXPLANATION OF PLATE VIII.

Fig. 1. An injection of the bloodvessels of a racemose gland, as seen in a very thin section. Medium enlargement.

Fig. 2. Scheme of the relations and distribution of the bloodvessels of the kidney. Low power. (After Ludwig.)

A. External portion of the cortex; *c* being the limiting capsule. *B.* The cortex. *C.* Boundary layer. *D.* The medulla. *E.* The apex of the papilla.

a, Portion of a small artery coursing along the boundary between the cortex and medulla,—it gives off an external twig (inter-lobular branch), which at varying intervals distributes an afferent arteriole to a Malpighian glomerulus, *m*; v, corresponding vein which receives an analogous external (inter-lobular) branch,—the latter collects blood directly from the efferent vessels of the glomeruli, *m*, and from (*r*) the capillary network (*rete mirabile*) surrounding the tortuous uriniferous tubes of the renal cortex, and it drains the renal medulla directly through bundles of *venulæ rectæ*, which empty into the inter-lobular vein as represented at v, on the left of the figure. Corresponding to the venulæ rectæ are the *arteriolæ rectæ*, not represented in the diagram, which arise at the base of the inter-lobular arterial twigs.

Fig. 3. Arrangement of bloodvessels in an intestinal villus. High power.

a, Arteriole; *v*, collecting venule; *c*, capillary plexus.

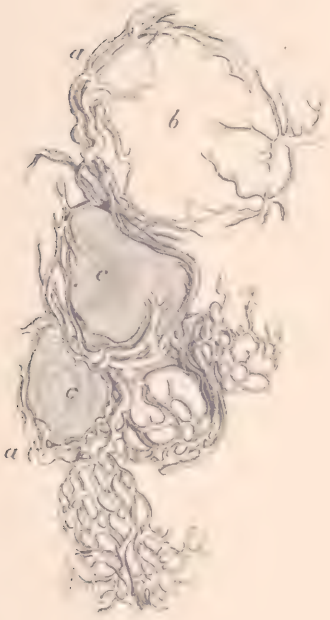
Fig. 4. Arrangement of bloodvessels in a filiform papilla of the tongue. High power.

a, Arterioles; *v*, collecting venules; *l*, capillary loops.

Fig. 5. Arrangement of minute bloodvessels in the muscular tissue of the tongue. Medium enlargement.

a, Arteriole; *m*, capillary plexus, the long axis of whose meshes corresponds with the length of the muscular fibre; *t*, capillaries running with muscle-bundles, which are vertical to the surface of the section.

Fig. 1.



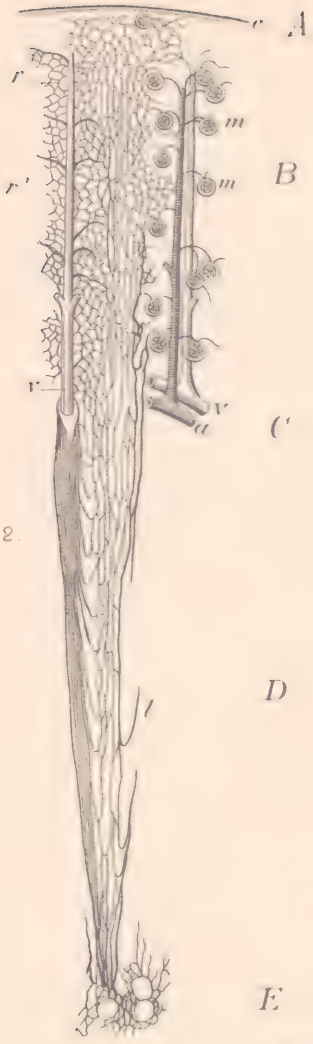


Fig. 2.

Fig. 3.

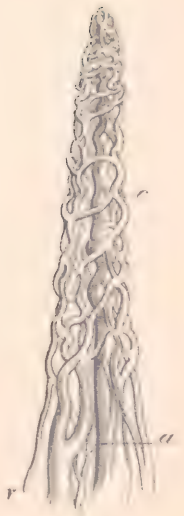


Fig. 4.



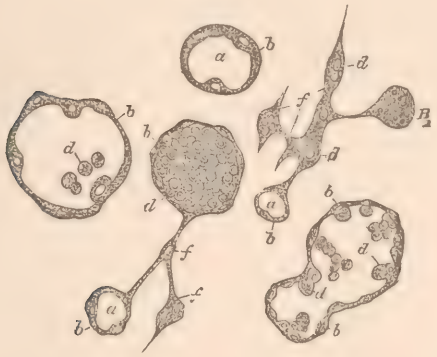


Fig. 5.

nective-tissue corpuscles at some distance from a capillary and not in direct communication with it, and thereby influence the formation of hollow protoplasmic tubes, which finally form a connection with the capillaries.

Those connective-tissue corpuscles which take part in the formation of new vessels, Ranvier regards as cells of special function, namely, the formation of vessels. He has called them *vasoformative cells.*

Fig. 41.



VARIOUS FORMS OF MOTHER-CELLS (SO-CALLED VASOFORMATIVE CELLS) UNDERGOING DEVELOPMENT INTO BLOODVESSELS, FROM THE MIDDLE LAYER OF THE CHICK'S BLASTODERM (KLEIN).—*a.* Large mother-cells vacuolated, forming the rudiments of vessels. *b.* Their walls, formed of protoplasm, with nuclei embedded and in some cases more or less detached and projecting. *d.* Blood-corpuscles. *f.* Small mother-cells—vacuolation commencing. *B.* Mother-cell in which only obscure granular matter is found.

In the development of new capillary bloodvessels from connective-tissue corpuscles, the elements of the blood are sometimes formed in small numbers, by a process similar to that of the original formation of blood and bloodvessels in the embryo. They may more or less completely fill the channels of the vasoformative cells, even before a communication is effected with the lumen of a previously-formed capillary.

The method of formation of the earliest bloodvessels in the embryo is essentially identical with that by which a so-called vaso-formative cell of the young or adult animal is transformed into a capillary. The bloodvessels are thus derived from the middle layer of the blastoderm.

Arrangement of the bloodvessels.—By branching the arteries diminish in calibre until the arteriole is reached. These, after running a short distance, almost always pass into a capillary network, which in its turn yields its blood to a collecting venule. In a few instances, however, the arterioles discharge their blood into the veins without the intermediation of capillary vessels. This is the case, for example, in the matrix of the nails, and in the ends of the fingers and toes. In the cavernous tissue of the genital organs a similar direct communication between the arteries and veins exists. Like the arteries, the veins also vary their diameter as branches are received. This is not so, however, with the capillaries, whose calibre is neither increased nor lessened by ramifying. The branch is usually of the same size as the capillary from which it receives its blood and the one into which it empties.

The distribution of the terminal bloodvessels varies according to the arrangement of the elements of the tissues in which they ramify. (Refer to descriptive text accompanying Plate VIII.)

NERVOUS TISSUE.

The nervous system comprises nerve-centres, peripheral terminations, conducting fibres uniting them, commissural fibres running from centre to centre, and a connective-tissue framework.

The whole nervous apparatus has generally been considered under two divisions, the cerebro-spinal system and the sympathetic system.

In the cerebro-spinal system we have nerve-centres constituted by nerve-ganglia, or *gray substance*, and conducting fibres, or *white substance.* From these centres nerves pass to various parts of the economy.

CEREBRO-SPINAL NERVES.

Nerve-sheath.—Cerebro-spinal nerves, after leaving their centres, are surrounded by a sheath of white fibrous connective-tissue, in which there is a certain amount of yellow elastic tissue.

At the exterior this fibrous tissue is somewhat denser than ordinary loose connective-tissue, and presents characters very similar to those of the cutis. Within this denser envelope the fibrous bundles and other elements are arranged in a manner analogous to the loose connective-tissues elsewhere.

The arteries and veins of the nerve-trunk ramify in this loose tissue, and the lymph also courses through it. As in other loose connective-tissue, adipose vesicles may be found between the fibres. This fibrous tissue is technically known as the *epineurium*—a continuation of the dura mata. A cerebro-spinal nerve contains, within the epineurium, one or more bundles of individual nerve-fibres. Immediately around the bundle of the nerve-fibres the connective-tissue of the epineurium becomes condensed into a laminated enveloping membrane—the *perineurium*—a continuation of the arachnoid. Between the lam-

inæ of the perineurium exist shallow lymph-spaces, containing connective-tissue elements, and partially lined by endothelium. The perineurium may inclose a single bundle (*funiculus*) of individual nerve-fibres, or it may ensheathe a number of such bundles, and constitute what has been termed a *nerve-fasciculus*.

Neuroglia.—In the simple funiculus the nerve-fibres are more or less closely packed side by side, imbedded in a soft, semifluid, somewhat granular substance, in which are scattered a few very fine connective-tissue bundles, a number of minute individual fibrillæ, and some flat and branched connective-tissue corpuscles. In this tissue (the *endoneurium*—a continuation of the neuroglia), run the capillary vessels, with much elongated meshes. As the endoneurium approaches the perineurium, it often becomes condensed into a more resistant layer, which is slightly separated from the inner lamina of the perineurium by a thin encircling lymph-space (a continuation of the subarachnoid space). At very numerous points this lymph-space is crossed by uniting trabeculæ of connective-tissue, and is everywhere lined by a layer of endothelia. When the perineurium ensheathes a number of funiculi, the latter are separated from each other by more or less complete partitions of the endoneurium, consisting of fibrous septa from the inner surface of the perineurium.

The fine connective fibrillæ of the endoneurium between the nerve-fibres are often closely interlaced around the nerve-cylinders as if to constitute for the latter a special protection. The endoneurium, besides carrying the capillary bloodvessels, is permeated by a network of capillary lymph-spaces.

Nerve-fibres, medullated and non-medullated.—The nerve-fibre, nerve-cylinder, or nerve-tube will be now described. When an ordinary cerebro-spinal nerve is cut across transversely, after proper hardening, the section offers, under a moderate power of the microscope, an appearance well represented in fig. 1, Plate IX. Within the perineuria (*c*), which present circular sections, are cross-cuts of simple bundles or funiculi of nerve-tubes. In the granular ground-substance (the endoneurium) are a few delicate fibrous bundles. Scattered more or less unevenly through the endoneurium are seen small, round, light spots, and in or near the centre (*d*) of each is a dark dot. The latter corresponds to the central or conducting fibres (the *axis cylinder*) of the nerve-tube, and the light ring around it is an ensheathing insulating cylinder of fatty material (*the medullary sheath*). These light, circular, dotted spots are sections of *medullated nerve-fibres*. Each considerable bundle of nerves contains, besides the medullated tubes, a number of *non-medullated nerve-fibres*.

The fully-developed medullated nerve-fibre, when fresh and properly prepared, presents the following characteristic structures: the axis-cylinder, the medullary sheath, and the sheath of Schwann, or neurilemma (Figs. 42–46).

a. The *axis-cylinder* is a finely-fibrillated cord running nearly in the axis of the nerve-tube. It consists of a small bundle of extremely fine unbranched fibrils, held very closely together by an albuminous semifluid cement-substance, which often contains very minute granules arranged in rows between the fibrils. (*b*, Fig. 43.)

Fig. 43.

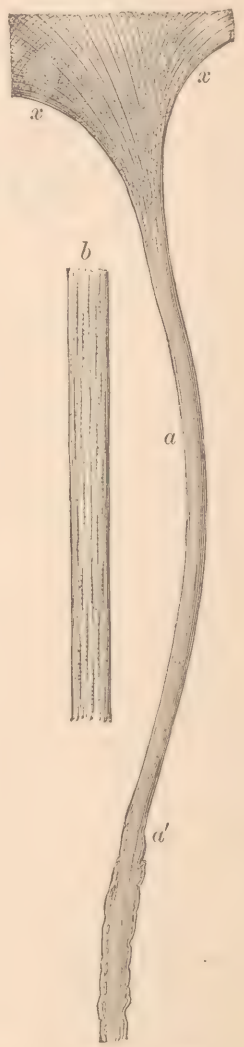
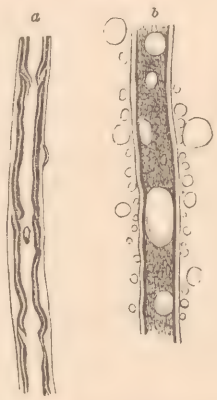


Fig. 42.



Diagram of Structure of Medullated Nerve-Fibre.—1. Neurilemma or sheath of Schwann. 2. Medullary sheath. 3. Axis-cylinder. (*Carpenter.*)

Fig. 44.



Nerve-Tubes.—*a*. Nerve-tube of the common European Eel in water. The delicate line on its exterior indicates the neurilemma. The dark double-edged inner line is the white substance of Schwann, slightly wrinkled and divided into bevelled segments. *b*. The same in ether. Several oil or neurine globules have coalesced in the interior, and others accumulated around the exterior of the tube. The white substance has in part disappeared. Magnified 300 diameters. (*Gray.*)

Axis-cylinders of Nerves.—*a*. Axis-cylinder, showing its fibrillar structure; at the upper part, *x*, *x*, it is seen to arise from a ganglion-cell, only partially represented, and to become inclosed by a medullary sheath at *a'*. *b*. Naked axis-cylinder, from the dorsal region of the spinal cord of the Ox. The medullary sheath has been removed. High power. (*Stricker.*)

b. The *medullary sheath* enveloping the axis-cylinder is not, as formerly supposed, a continuous uninterrupted

insulating tube. It is composed of a great number of short *tubular sections*, placed end to end, or imbricated. The ends of these sections are bevelled as represented very poorly in *a*, Fig. 44. Each of these bevelled-edged tubal sections consists of a fatty, semifluid substance, held within the meshes of a fine reticulum (Klein). This fatty substance has long been known as *neurine*. Water, pressure, and various reagents cause the semifluid fat of these sections, which normally is homogeneous, to break up into granules and drops. The medullary cylinder then becomes coarsely granular, and if the neurilemma be broken the fat extrudes in drops of considerable size, as shown in *b*, Fig. 44.

Fig. 45.

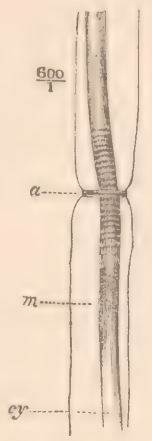


HUMAN NERVE-TUBES, highly magnified. Four of them are fine, one being varicose, and two of middling thickness and of simple contour; whilst three are thick, two of which are double-contoured, and one incloses grumous contents. (*Gray.*)

c. The *neurilemma*, or sheath of Schwann, is a delicate, elastic, homogeneous membrane, which envelops the medullary cylinder as a continuous tube. It is the analogue of the sarcolemma. Between the neurilemma and the medullary sheath is a thin lymph-space. The axis-cylinder and the surrounding medullary sheath are also slightly separated by a thin lymph-space. This latter lymph-space is probably in communication with the outer lymph-space beneath the neurilemma, by means of the spaces between the bevelled ends of the tubal sections of the medullary cylinder.

Nodes of Ranvier.—The neurilemma is not a tube with straight sides, and even calibre from one end to the other, but presents at more or less regular intervals sharp *annular constrictions* (*a*, Fig. 46), which divide the nerve-tube into segments. At the place of these annular constrictions, first described by Ranvier, a septum from the neurilemma passes across the nerve-fibre interrupting all of its parts except the axis-cylinder and the lymph-space immediately surrounding the latter. When a perfectly fresh and uninjured medullated nerve-fibre is treated by nitrate of silver, and exposed to light, the annular constriction becomes very distinct. If the nerve is submitted long enough to the action of the silver salt, the latter will penetrate to the periaxial lymph-space around the axis-cylinder, and extend along it for a little distance. When this is the case the surface of the axis-cylinder is covered by transverse markings (*lines of Frommann*), which are due to coagulations in the lymph-space. In consequence of this dark staining of the annular constrictions, and of the axis-cylinders for some distance above and below them, a *dark cross* becomes conspicuous. These constrictions are known as the *nodes of Ranvier*, and the portions of the nerve-cylinder between the constrictions are known as *inter-annular segments*. Each interannular segment comprises a number of bevelled-edged imbricated tubular sections of the medullary sheath, and also contains a flattened nucleated corpuscle. The nucleus of this cell consists of a fine reticulum and an enveloping membrane of double contour. It is a flattened-oval in shape, and is surrounded by a small amount of protoplasm which also contains a fine reticulum. The corpuscle is flattened upon and partially sunk into the surface of the medullary sheath, sometimes extending across one or more bevelled sections of the cylinder. It has no connection with the neurilemma. It is the analogue of the muscle-corpuscle, and has been named the *nerve-corpuscle*.

Fig. 46.



NERVE-FIBRE FROM THE SCIATIC NERVE OF THE RABBIT AFTER THE ACTION OF NITRATE OF SILVER.—*a*. Ring formed by thickened membrane of Schwann. *m*. White substance of Schwann rendered transparent by glycerin. *Cy*. Cylinder-axis, which just above and below the level of the annular constriction presents the lines of Frommann. (*Frommann.*)

Size of nerve-fibres.—The size of a medullated nerve-fibre varies according to the diameter of the axis-cylinder, and the thickness of the insulating sheath or medullary cylinder. The thickness of the medullary sheath to some extent varies with the distance to which the nervous impulse is to be conducted. The greater the course the nerve-fibre has to traverse, the greater the thickness of the insulating cylinder, is a rule which has numerous exceptions.

In the nerve-centres the medullary sheath is comparatively thin, except in certain tracts of the spinal cord, where fibres which run a great distance are located.

As the medullary nerve-fibre approaches its peripheral termination, its medullary cylinder gradually becomes thinner and thinner until it entirely disappears, leaving only some flat nerve-corpuscles between the neurilemma and the axis-cylinder. There are many nerve-fibres of this structure to be seen in nearly every section of a nerve-bundle. They are generally scattered around unevenly among the fibres which are still medullated. In a given nerve-bundle the medullary fibres may be nearly uniform in size, or they may have very different diameters.

Division of nerve-fibres.—In their course the nerve-bundles generally branch in order to widen the extent of their distribution. In some instances branches derived from two or more bundles are bound together to form a nerve-bundle. In this manner a plexus of nerve-bundles may be formed within a common epineurium. Occasionally, also, complete nerves may branch and form nerve-plexuses.

While the branching of whole nerves and of their constituent bundles is of universal occurrence, it has been doubted if the individual medullated fibres ever divide. Some well-reputed authors have in recent years both described and figured an occasional bifurcation of medullated nerve-fibres, especially when near their peripheral termination. This bifurcation takes place invariably at one of the nodes of Ranvier. The axis-cylinder divides, and each branch is enveloped in a neurilemma and medullary sheath which are continuations of those which surround the fibre above the point of division.

Microscopic nerve-bundle.—In branching, a nerve becomes smaller and smaller and its constitution less and less complex until a microscopic size is reached. This microscopic nerve may consist of a single small bundle of medullated and other fibres ensheathed in a perineurium, which, instead of being formed by dense lamellated connective-tissue, is represented by a delicate film of connective-tissue. The external surface of the endoneurium, as in the larger nerves, is still covered by an investment of endothelia. The appearance of such a microscopic nerve, after it has been withdrawn from its perineural sheath and submitted to the action of nitrate of silver and light, is very well represented in Fig. 47.

Fig. 47.



Nerve-Funiculus of the Tail of a Mouse, after Impregnation with Nitrate of Silver.—Large flat endothelial cells are seen covering its surface. For explanation of the small crosses see preceding figure. (*Ranvier.*)

A microscopic funiculus of this character continues to divide and subdivide until the smallest microscopic medullated nerve is reached, inclosed in a perineurium composed of a single layer of endothelial cells.

These smallest medullated nerves are not infrequently slightly moniliform—an irregularity of outline due to the accumulation at intervals of lymph or periaxial cement-substance in the lymph-space between the cylinder-axis and the medullary sheath (Fig. 45).

The nerve-fibre finally loses its medullary sheath. From this point it passes through the tissue with a simple covering of neurilemma and occasional nerve-corpuscles. From time

EXPLANATION OF PLATE IX.

Fig. 1. Transverse section of a small branch of a cerebro-spinal nerve. Medium enlargement.

a, Common sheath; *b*, lymph-space within it; *c*, *perineurium* carrying bloodvessels, *v*, and lymph-vessels; *d*, axis cylinders of medullated nerve fibres. These fibres are collected together into bundles, inclosed within a sheath, which consists of a condensation of the connective-tissue of the *perineurium*. The individual nerve fibres constituting such a bundle are separated from each other by a delicate tissue known as the *endoneurium*.

Fig. 2. Minute subdivisions of the nerves in the superficial layer of the cornea, termed the *subepithelial plexus*, as seen in the cornea of a Rabbit after treatment with chloride of gold. High power.

Fig. 3. Connective-tissue elements of the perineurium of a cerebro-spinal nerve. Very high power. (After Ranvier.)

f, Connective-tissue bundles; *c*, flat connective-tissue or endothelial-cells.

Fig. 4. A minute bundle of medullated nerve-fibres in the tongue of a Cat, showing axis-cylinders, *c*, and nuclei of the neurilemma, *n*. High power.

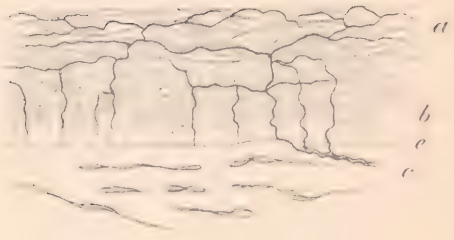
Fig. 5. Vertical section of anterior epithelium, *a*, *b*, and superficial layers, *e*, *c*, of the fibrous tissue of a cornea stained with gold, showing the penetration of the nerve-filaments between the corneal epithelium, and the formation there of an inter-epithelial network of minute nerve-fibres. (After Cohnheim.)


b
d
c
d
a
b
a
c


d
c
b
a


n
n
c
c


f
c
c
c


a
b
c
c

to time the axis-cylinder splits up into branches, which, by further division, become so small as to be composed of an extremely small number of fibrils loosely bunched together. In these minute divisions of the axis-cylinder the neurilemma ultimately disappears, and the only remains of the original envelopes of the medullary nerve-fibre are a few flattened connective-tissue cells which at scattered points wrap more or less completely around the small bundles of nerve-fibrils. By this time the nerve-fibrils have become beaded (fig. 2, Plate IX.). After the axis-cylinder has lost its medullary sheath and has branched in the manner above indicated, the nerve-fibrils are frequently collected again into delicate fibrillar bundles to form networks. Notwithstanding these numerous ramifications and anastomoses of collections of minute nerve-fibrils, it is believed that an individual fibril itself never divides.

Fibres of Remak.—Attention has thus far been called to three different forms of nerve-fibre. It is now proposed to consider a fourth variety—the gray or gelatinous fibre or the *fibre of Remak*. This does not sensibly differ from a variety of medullary fibre already described, namely, the one which has lost its medullary sheath, and is composed simply of neurilemma, nerve-corpuscle, and axis-cylinder.

Fig. 48.



A Small Nerve-Branch from the Sympathetic of a Mammal. — *d*. Two dark-bordered nerve-tubes among a number of Remak's fibres, *b*. (*Frey.*)

In the cerebro-spinal nerves the medullated fibres greatly preponderate over the non-medullated or gelatinoid fibres. In the sympathetic nerves this order is usually, although not always, reversed, and the medullated nerves are frequently finer than in the cerebro-spinal nerves. In nerves of a mixed character the sympathetic fibres may run in a bundle by themselves or they may be indiscriminately mixed with the other fibres. Of the medullated nerves, the sensory fibres, as a rule, retain their medullated sheath longer than do the motor fibres.

PERIPHERAL TERMINATIONS OF NERVES.

This subject may be considered under two general heads: *a*, the peripheral termination of sensory nerves; and, *b*, those of motor nerves.

a. Peripheral terminations of sensory nerves.—As has been already indicated, the smallest microscopic medullated nerve consists of a perineurium surrounding a bundle of nerve-fibres. Some fibres lose the medullated sheath earlier than others. When the nerve is very near its termination, usually the medullary cylinder and the neurilemma disappear from all the fibres within the investing perineurium. The fibrils of the different axis-cylinders, being now more free than before, interlace in such a manner that the nerve-bundle appears much like a longitudinal network of fibrils collected into a cord. In the skin and mucous membranes, near the surface, and in many other locations, these non-medullated branches ramify and unite into a plexus; each limb of the plexus, even when it comprises not more than two nerve-fibrils, is still invested by a delicate membrane which is the representative of the perineurium. Along the course of these ramifications, and especially at the nodal points of the plexus, are a few nuclei.

Subepithelial plexuses and networks.—In the skin and mucous membranes a plexus exists beneath the epithelial covering. Hence it has been called the *subepithelial plexus* or ground-plexus. From this subepithelial plexus, single, fine, beaded fibrils, or small collections of such fibrils, come off and unite with each other into a network of meshes of various sizes and outlines. This network of nerve-fibrils is located immediately beneath the epithelium, and has consequently been called the *subepithelial network* (fig. 2, Plate IX.).

Intercellular networks.—Some of the branches of the subepithelial network enter the layer of epithelium, passing in the intercellular cement between the epithelial cells. These branches ramify among the epithelia to form an *intercellular network* of single-beaded fibrils (fig. 5, Plate IX.). In some locations the subepithelial networks are peculiarly arranged with respect to the direction of the fibrils and the consequent outline of the meshes. Beneath the epithelium of the cornea, for example, the branches which come from the ground-plexus give origin to ramifications, which with the stem whence they arise present an appearance that has been compared to the cat-o-nine-tails (fig. 2, Plate IX.).

There is a great diversity of opinion as to whether the nerve-fibrils from the subepithelial plexus simply end in the cement-substance, between the epithelial cells, in a network such as above indicated, or whether they terminate by free extremities, some of which communicating with the stellate cells among the epithelium, others extending to the surface.

It seems to be certain that some of the nerves of special sense terminate among epithelial cells. In the Schneiderian membrane the olfactory nerves form a subepithelial plexus, fibres from which terminate in certain rod-shaped elements (*b*, Fig. 49), the superficial ends of which reach the surface between the columnar epithelial cells of that membrane. The terminations of the optic nerve are conical and rod-like organs, which are imbedded between epithelial cells. The auditory nerves probably have an analogous ending. The gustatory nerve has a peculiar terminal organ (the taste-bulb) implanted among the lingual epithelium (Fig. 50).

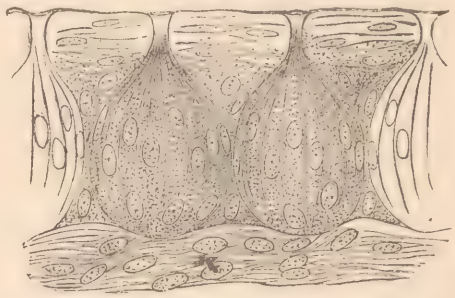
Fig. 49.



Cells of the Olfactory Mucous Membrane. —*a*, *b*, *c*. After Schultze. *d*, *e*, *f*. After Lockhart Clarke.

In some kinds of connective-tissue, also, sensory nerves seem to end in complicated nervous networks. In the cornea, for example, besides a superficial subepithelial nerve-plexus, above mentioned, there is also a deep plexus which supplies the posterior lamellæ. Fig. 1, Plate X., accurately represents (according to Klein) the manner of distribution of the minute beaded fibrillæ to a deep stratum of the cornea of a rabbit. *a*. Is a part of the ground-plexus (or nerve of the first order)—a bundle of interlacing, free nerve-fibrillæ, inclosed by an extremely delicate sheath, representing the perineurium. *b*. Are branches from the ground-plexus (or nerves of the second order) still possessing an investing sheath, but comprising only a small number of fibrils—they also anastomose to form a network. *c*. Are

Fig. 50.



Gustatory Bulbs from the Lateral Gustatory Organ of the Rabbit.—High power. (*Stricker.*)

single, minute, beaded fibrils (nerves of the third order), which arise from the network formed by *b*, and pursue a rectilinear course among the fibrous bundles of the connective-tissue—they unite with fibres of a similar appearance to form a network of rectangular meshes. *d*. Are nerves of the fourth order, still finer beaded isolated fibrils, which arise from the nerves of the third order, and form a network with very small, irregular meshes. The fibrils of this last minute network frequently appear to be in contact with some part of the surface of the corneal corpuscles, the analogues of connective-tissue corpuscles. Opinion is evenly divided as to whether this last network is to be regarded as the peripheral termination of these nerve-fibrils, or whether still more

EXPLANATION OF PLATE X.

Fig. 1. Represents the distribution of the nerves in the depth of the cornea. Very high power. (After Klein.)

a, Nerve of the first order; *b*, nerve of the second order; *c*, beaded nerve of the third order, forming a rectangular network; *d*, beaded nerve of the fourth order, which forms a network, perhaps upon the surface of the branched corneal corpuscles, which latter, with their branches (*e*) and their nuclei, are represented in the figure.

Fig. 2. End bulb, *b*, and medullary nerve, *c*, *d*, of the conjunctiva of a Calf; *a*, axis-cylinder termination of the nerve within the bulb. High power. (After Krause.)

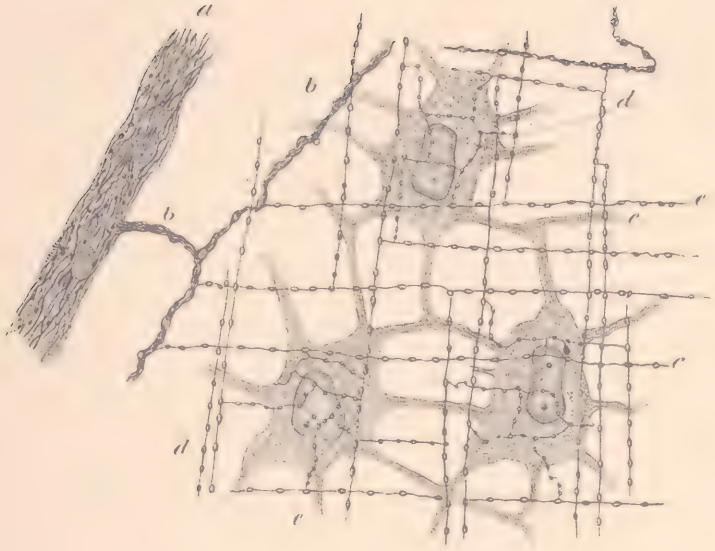
Fig. 3. Pacinian corpuscle. High power.

n, Axis-cylinder of medullary nerve-fibre; *e*, termination of the sheath of Schwann in the fibrous lamellæ, *d*, of the Pacinian body; *a*, *c*, the axis-cylinder; *b*, its division and termination near the end opposite the entrance of the nerve-fibre.

Fig. 4. Distribution of nerves in the wall of a small arteriole. High power. (Arnold.)

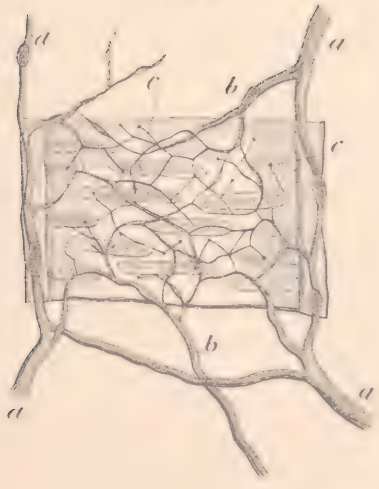
a, Larger nerve-twigs which branch into minute subdivisions, some of which, according to Arnold, terminate in the nucleoli or within the nuclei, *c*, of the smooth muscle-fibres of the tunica media.

Fig. 5. Shows the relations of the minute nerves to the walls of a capillary bloodvessel. High power. (After Klein.)











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minute fibrils come off from it, and enter the substance of the corneal corpuscles to terminate therein.

Besides the foregoing modes of peripheral distribution of sensory nerves, there are yet to be mentioned certain special structures in which nerves of this character frequently end. The most important of these are the Pacinian corpuscles, tactile corpuscles, and the end-bulbs of Krause.

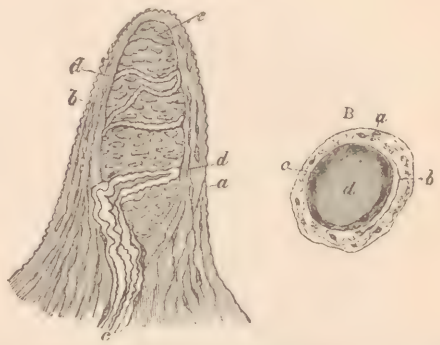
End-bulbs of Krause.—These organs are met with in small numbers at the peripheral ends of some of the medullated nerves terminating in the deeper layers of the conjunctiva, especially near the cornea. They appear to have a simple plan of structure.

b, fig. 2, Plate X., represents, under a low power, the simplest form of such an end-bulb from the conjunctiva of the calf. In this case its outline is somewhat cylindrical, with rounded ends, and it is fixed upon the end of a medullated nerve-fibre, *c*. The nerve-fibre is seen to pass nearly straight along the axis of the elongated bulb, and to terminate in a slightly tapering extremity, near the end opposite the point of entrance. In man the end-bulbs of Krause are often more or less spherical, and the nerve-fibre, after entering the organ, instead of pursuing a direct course, is frequently more or less convoluted, and even sometimes branched. The nerve-fibre upon which it is placed possesses a distinct perineurium, enveloping a neurilemma, within which is an axis-cylinder insulated by a medullary sheath: all these parts exhibit their usual characteristics. When the nerve reaches the end-bulb the perineurium spreads out and envelops it, forming in some instances a slightly laminated sheath. Ordinarily, but not always, the nerve-fibre loses its medullary sheath upon entering the bulb. The axis-cylinder enters the body of the bulb and passes to the opposite end, either in a straight or somewhat wavy course, or after first forming several tortuous curves or convolutions. It may end in a tapering extremity, extend into a knot, or divide into two or more branches, each ending in a terminal enlargement. Among the convolutions nuclei are generally found in some numbers, embedded in a slightly granular substance. Occasionally the medullated sheath continues for some distance along the convolution.

Bulbous nerve-terminations somewhat similar to those above described are found in considerable numbers upon the genital organs.

Tactile corpuscles.—The *tactile corpuscles* are nerve-terminations of much wider distribution than the end-bulbs of Krause, and are somewhat more complex in structure. They are found mainly in the apex of papillæ of the skin, and because of their location in greatest numbers at the ends of the fingers, and upon other surfaces endowed with the most delicate sense of touch, they have been called tactile bodies or corpuscles. In their simplest form they consist of an enlargement shaped somewhat like a pine cone upon the end of a medullated nerve-fibre. (Fig. 51.) The

Fig. 51.



TACTILE CORPUSCLE.—A. Side view of a papilla of the hand. *a*. Cortical layer. *b*. Tactile corpuscle, with transverse nuclei. *c*. Small nerve of papilla, with neurilemma. *d*. Its two nervous fibres running with spiral coils around the tactile corpuscle. *e*. Apparent termination of one of these fibres. B. A tactile papilla seen from above, so as to show its transverse section. *a*. Cortical layer. *b*. Nerve-fibres. *c*. Outer layer of the tactile body, with nuclei. *d*. Clear interior substance. From the Human subject, and treated with acetic acid. Highly magnified. (*Gray*.)

perineural sheath of the fibre thickens and spreads out to form a tolerably thin laminated fibrous covering or capsule for the touch-corpuscle. The main contents of this capsule are large, clear, vesicular, nucleated cells frequently flattened from above downward, and piled one upon the other somewhat like the disks of a Voltaic pile. The medullated nerve-fibre penetrates the touch-corpuscle at its deep end, sometimes losing its medullary sheath, sometimes retaining it for some distance within the body of the corpuscle. Upon entering the body of the tactile corpuscle the nerve-fibre coils around the surface of the previously mentioned cells in a sort of ascending spiral, which, sinking into the indentation between the cells, is ultimately lost to view. Fine fibrils, probably continuous with the axis-cylinder of the coils between the cells, wind around the surface between the coils, and cause an appearance of fine transverse fibrillation. Exactly how the nerve fibrillæ terminate in this complex body is not known.

Pacinian corpuscles.—The *Pacinian corpuscles*, in which some medullated sensory fibres end, are comparatively large ovoid bodies, which in favorable locations are distinctly visible to the naked eye. They are most frequently found in the subcutaneous and submucous loose cellular tissue, and in the loose connective-tissue between bundles of muscle-fibres.

They are also not infrequently present in serous coverings. The mesentery of the cat is the most favorable position in which to study them. They consist of a thick, dense capsule formed by a large number of thin concentric membranous laminæ of white fibrous tissue (Fig. 52, and fig. 3, Plate X.). These laminæ are

Fig. 52.



PACINIAN CORPUSCLE with its system of capsules and central cavity —*a*. Arterial twig, ending in capillaries, which form loops in some of the intercapsular spaces; one penetrates to the central capsule. *b*. The fibrous tissue of the stalk prolonged from the neurilemma. *n*. Nerve-tube advancing to the central capsules, there losing its white substance, and stretching along the axis to the opposite end, where it is attached by a tubercular enlargement. (*Gray*.)

slightly separated by very thin strata of semifluid substance, in which is imbedded an extremely thin—probably elastic—film consisting of a single layer of flat endothelial cells. In sections of the Pacinian corpuscle, such as the figure represents, the nuclei of these endothelial cells appear as rows of fusiform bodies between the concentric lamellæ. The capsule incloses a narrow axial space of an elongated, somewhat cylindrical form, usually having a slight enlargement, sometimes even a bifurcation of the upper end. This capsule fits over the extremity of the nerve-fibre in the following manner. The perineural sheath of the medullated nerve-fibre thickens and becomes continuous with the outer lamellæ of the fibrous capsule of the corpuscle. The sheath of Schwann and the medullary sheath are generally lost, as the nerve-fibre penetrates the thickness of the capsular covering. By the time that the axis-cylinder has reached the axial space of the capsule it has usually lost all of its coverings. It passes up the central portion of the space until the enlargement at the end is reached. Here the axis-cylinder terminates generally in a single button-shaped or cauliflower knob. Sometimes just before reaching this point the axis-cylinder bifurcates or trifurcates, each division ending in a similar enlargement.

Instead of the axis-cylinder pursuing a nearly rectilinear course in the axial space of the capsule it may be more or less convoluted. Sometimes the medullary sheath continues into the lower part of the axial space. This central space, besides containing the terminal ends of the nerve-fibrils, is filled with a semifluid albuminoid substance. Its walls are covered with a layer of endothelial plates. It is doubtful whether the individual fibrillæ of the axis-cylinder terminate in the upper portion of the axial space by free extremities with a minute bulb, or whether they end in an extremely fine terminal network.

Besides a nerve-fibre, each Pacinian corpuscle is supplied with a minute afferent and efferent blood-vessel and an intermediate capillary plexus. The bloodvessels usually enter and emerge with the nerve-fibre, but sometimes they pass into the capsule at the opposite extremity. The capillaries are distributed between the lamellæ of the fibrous capsule, and never reach the central axial space. Occasionally, instead of one Pacinian body being connected with a nerve-fibre, as is usual, the fibre may divide at a node of Ranvier, and each branch end in a Pacinian corpuscle. The group of corpuscles is then often connected together by longer or shorter bands of fibrous tissue.

Hair-bulbs.—The *hair-bulbs* receive the terminations of medullary nerve-fibres, and are sometimes exquisitely sensitive.

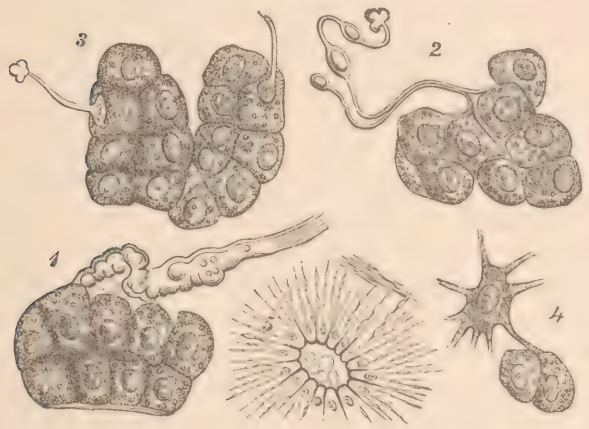
Nerve-endings in gland-cells. — Pflüger, among others, has carefully studied the relations of nerves to some of the secreting glands, and has found nerve-fibres in direct connection with the nuclei of cells in the acini, and even in the ducts of glands. Fig. 53 shows four modes of direct termination of nerve-fibres in gland-cells.

b. Termination of motor nerves.—The *motor nerves* have their peripheral endings among muscle-fibres.

Nerve-endings in smooth muscle.—In *smooth muscles* their character, distribution, and termination are not the same as in striped muscle. Non-medullated nerve bundles run and branch in the loose connective-tissue between the bundles of muscular fibres. They are enveloped in a cellular sheath, which is a representation of the perineurium, and they are composed of

interlacing fibrils which have no medullary sheath, or sheath of Schwann, but are covered at intervals by flat cells, which are probably the remains of the nerve-corpuscles belonging to the medullary sheath.

Fig. 53.



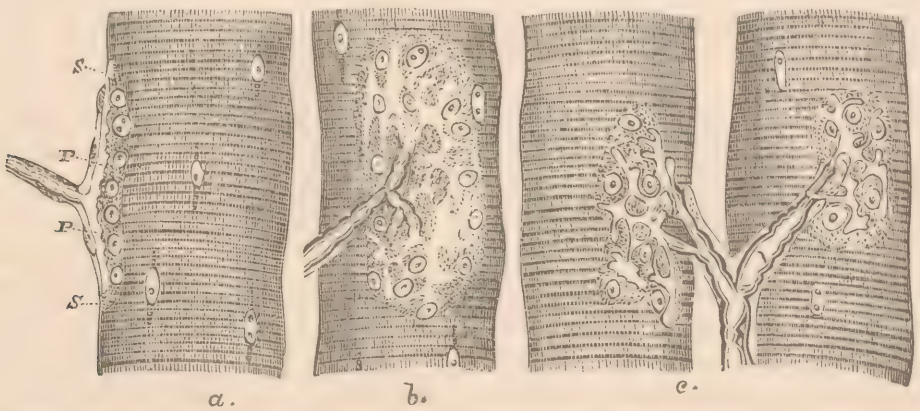
Modes of Termination of the Nerves in the Salivary Glands.—1 and 2. Branching of the nerves between the salivary cells. 3. Termination of the nerve in the nucleus. 4. Union of a ganglion-cell with a salivary cell. 5. Varicose nerve-fibres entering the cylindrical cells of the excretory ducts. (*Pflüger.*)

Such branches communicate with their neighbors to form a plexus—the ground-plexus of Arnold. From this ground-plexus come off smaller branches composed of small groups of individual fibrils. These smaller branches are still covered by a cellular-sheath. They also unite into a plexus, which envelops the perimysium of primary bundles of smooth fibres—the intermediary plexus of Arnold. The intermediary plexus immediately enveloping the muscular bundles gives off branches composed of single beaded fibrils, which enter the endomysium and unite to form a delicate network surrounding the individual muscle-fibres. Some authors claim that this last network again gives off extremely minute fibrils, which penetrate the muscle-cell and end in the nucleus; others declare the network to be the peripheral termination of these nerve-fibres. Occasionally a few pear-shaped enlargements are met with upon the fine fibrils of this last network.

Fig. 4, Plate X., represents, according to Arnold, the nerve-supply of the smooth muscle-fibres in the walls of a small artery. Non-medullated bundles of fibrils, similar to those of the ground-plexus described above for smooth muscles, unite to form a ground-plexus in the tunica adventitia. (It should be mentioned here, in passing, that in the nodes of these ground-plexuses of nerves in smooth muscle there are often located one or more cells, which many regard as ganglion nerve-cells.) This ground plexus gives origin to minute but still compound branches, which themselves again unite into a more delicate plexus—the intermediary plexus. This last plexus gives off single fibrils which enter the tunica media, pass between the individual muscle-cells, and unite there to form a fine network. The same difference of opinion exists as in the former case concerning the direct connection of the nerve-fibrils with the nuclei of the muscle-cells. In many places capillary bloodvessels are surrounded by networks of nerve-fibrils, as shown in fig. 5, Plate X.

Nerve-endings in striped muscle.—The termination of motor nerves in *striped muscle* is peculiar. The nerve-fibres preserve their medullary cylinder and sheath of Schwann until they enter the muscle-fibres. According to the investigations of the most recent authors, each individual muscle-fibre receives one or more medullated nerve-fibres. The nerve-fibre passes to the muscle-fibre obliquely, and enters the sarcolemma,—the neurilemma, or sheath of

Fig. 54.



Muscular Fibres of Lacerta, with the Terminations of Nerves in End-Plates of Kuhne.—*a.* Seen in profile. p. The nerve end-plates. s. The base of the plate, consisting of a protoplasmic mass with nuclei. *b.* The same seen in face, when a perfectly fresh fibre is examined, the nerve-ends probably being still excitable. *c.* The same as seen two hours after death from poisoning by curare. Highly magnified. (*Kühne.*)

Schwann, ending in and being continuous with the elastic envelope of the muscle-fibre (Figs. 37 and 54). The nerve-fibre, composed of a medullary sheath and axis-cylinder, penetrates the sarcolemma and passes into and is lost in a large flat body, located upon the substance of the muscle-fibre, called the *end-plate of Kühne*. Before disappearing in the substance of this end-plate the still medullated fibre may branch and the branches ramify upon the end-plate, each yet retaining its medullated sheath. Where the medullary sheath ends, the axis-cylinder spreads out into the surface of the end-plate, and is soon lost to view. The end-plate is usually more or less granular, and sometimes contains a considerable number of oval nuclei. The granular appearance is generally due to the presence of a minute reticulum, which may, perhaps, be continuous with the fibrils of the axis-cylinder. The nerve-fibrils are not known to pass into the contractile substance of the muscle-fibre. Some authors believe they have seen the branches of the nerve-fibre extend upon the surface of the sarcous substance beyond the end-plate.

Beale denies entirely this mode of ending of the nerves in striped muscles, and substitutes for the end plate of Krause within the sarcolemma a simple network of medullated nerve-fibres with a number of nuclei in the meshes, claiming that the network rests upon the outside of the sarcolemma.

NERVE-CENTRES.

The nerve-centres are constituted by *gray* or vesicular nerve-substance, and *white fibrous substance*. The latter consists of nerve-fibres in most respects similar to those which have already been described when considering the nerves, but they have no definite neurilemma. The nerve-fibres will, therefore, not occupy particular attention in this place.

The former, the gray matter, contains special cells of peculiar form and structure which have been called nerve- or *ganglion-cells*.

Neuroglia. — In the cerebro-spinal nerve-centres both nerve-fibres and nerve-cells are found imbedded in a soft finely-granular variety of connective-tissue which has received from Virchow the special name of *neuroglia*. In the gray substance of the cerebro-spinal centres it is possible, as we shall see below, that the neuroglia may possess peculiarities of function which are probably not common to the neuroglia of the white substance. The neuroglia of the latter consists of a semifluid, homogeneous substance containing a network of extremely minute fibrils which are probably of an elastic nature. At occasional intervals, among this minute elastic network, are to be seen branched connective-tissue corpuscles whose fine ramifications are in communication with the fine network already described. These branched connective-tissue corpuscles are known as *neuroglia-cells*. Between the medullated nerve-fibres of the white substance the minute fibrils of the neuroglia-network have mainly a longitudinal direction.

In the gray substance, the meshes formed by the neuroglia-fibres are extremely minute and are quite irregular and sponge-like. In addition to the neuroglia-network above mentioned, there is superadded a minute network of fine fibrils which are derived from the branching processes of the ganglion nerve-cells present in large numbers in the gray matter—a network difficult, if not impossible, to distinguish from that composed of simple neuroglia-fibres. This has been termed the *nervous reticulum of Gerlach*. Some investigators add to the neuroglia of the gray substance of the spinal marrow still another nervous reticulum, which derives its minute fibres from a repeated division, in the posterior portions of the cord, of nerve-fibres from the sensory roots. In this complex neuroglia of the gray substance the vessels, the ganglion-cells with their branches, and a limited number of medullated fibres, are imbedded.

Ganglion-cells.—The *ganglion-cell* is contained within a small lymph-space in the neuroglia. It is of an irregular outline more or less closely corresponding to the shape of the cell. The size of the latter is comparatively large, but different ganglion-cells vary widely in their dimensions. Some are relatively of enormous volume. The largest are usually found in the anterior horns of the spinal cord, and in the motor centres of the cerebrum. They also vary greatly in form. Some are oval without processes (*apolar*); some fusiform with one or more processes at either end (*bipolar*); but the majority of them have many branches which may come off at any portion of their surface (*multipolar*). The body of the ganglion-cell contains an intra-cellular network of fine fibrils. Nearly all the processes of these cells repeatedly branch dichotomously until the resulting fibres become

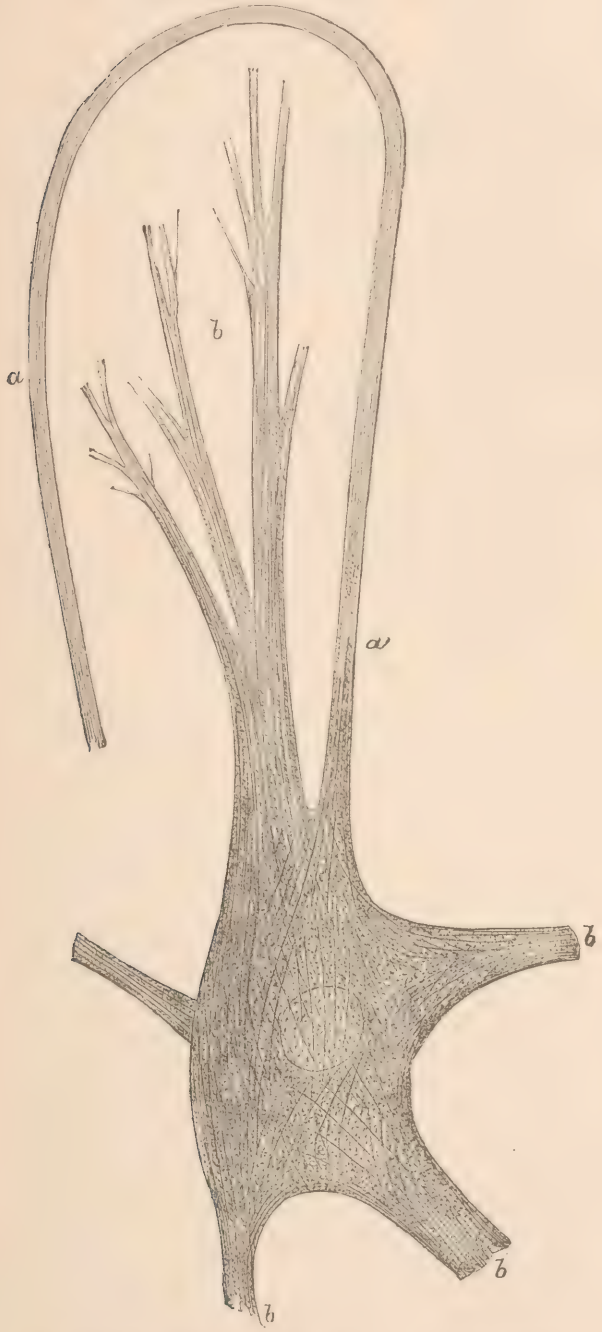
Fig. 55.



Stellate Nerve-cell, from the nucleus cervicis cornu (posterior vesicular column) of a Fœtus of six months, showing the minute reticulum formed by the dichotomous branching of the processes (nervous reticulum of Gerlach). Magnified 420 diameters. (*Carpenter.*)

extremely fine, when they form a minute network in the neuroglia—the nervous network of Gerlach above mentioned. Each one of these branching processes contains a continuation of the intra-cellular network, the meshes of which are narrow and greatly elongated in the direction of the length of the process.

Fig. 56.



A Medium-sized Ganglion-cell, from the anterior horn of the gray matter of the spinal cord of a Calf, isolated after a short maceration in serum containing a little iodine in solution. Magnified 600 diameters. Some of the processes (as at *b*) are abruptly broken off; *a* is the axis-cylinder process of Deiters. (*Stricker.*)

The fibres of the reticula of the processes spread out in the cell-body, and cause the latter to appear to be crossed in various directions throughout its substance by fine fibrillæ (Fig. 56, and refer also to fig. 2, Plate XI.).

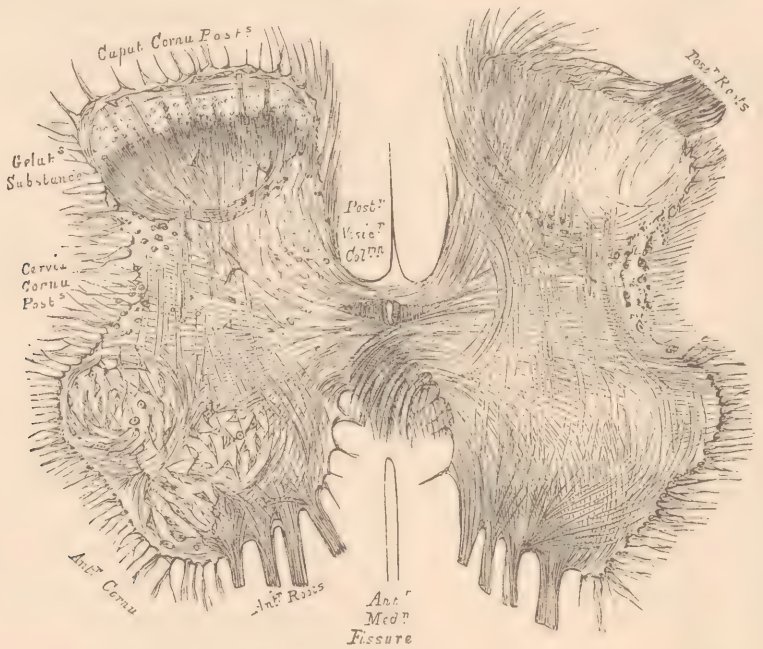
In the motor areas of the cerebro-spinal system are found large multipolar ganglion nerve-cells, of which one of the processes differs from the previously described branching processes in several respects. In the first place, the process is smaller at its connection with the body of the cell than are the others (*a*, Fig. 56). Secondly, as the distance from the cell increases, so also the process enlarges, until finally it becomes surrounded by a medullary sheath (*a*, Fig. 43). This process has been called the *axis-cylinder process of Deiters.* It has a distinct longitudinal fibrillation. Those branched ganglion nerve-corpuscles which possess an axis-cylinder process of Deiters on the one hand communicate with the motor nerve-fibres through their axis-cylinder process, whilst on the other hand they are united intimately with the nervous reticulum of Gerlach by means of their finely branching processes. Each ganglion-cell contains near its central portion a large spherical nucleus limited by a double-contoured membrane, and inclosing sometimes one or more distinct brilliant nucleoli. The nucleus, like the cell-body, is composed of an intra-nuclear network in connection with the intercellular reticulum. In the meshes of these reticula is inclosed a soft semifluid substance sometimes holding in suspension brownish-yellow pigment-granules. As has been already indicated, these ganglion-cells are suspended in lymph-spaces—the *pericellular lymph-spaces* which sometimes even in health may contain a small number of lymph-cells.

The ganglion-cells of the gray matter of the cerebro-spinal centres vary greatly in size, shape, and distribution.

Gray matter of the spinal cord.—In the spinal cord they are smallest in the posterior portion of the posterior gray horns, and are largest in the lateral portion of the anterior horns. Instead of being scattered evenly or irregularly throughout the gray matter of the cord, they are mostly collected into certain well-known groups which extend up and down the cord and form columns of cells. In Fig. 57, three such groups are represented in the anterior horn—the so-called internal, anterior, and lateral groups. It is thought by some authorities that these are the only ganglion-cells of the spinal cord which possess axis-cylinder processes, and a direct connection with medullated nerve-fibres. In front of and in the anterior

portion of the gelatinous substance in the posterior horn is another column. At the root of the posterior horns in the dorsal region there is still another column of ganglion-cells located near the posterior white columns (Clarke's column). Around the central canal or its remains is another aggregation of ganglion-cells. The finely-branched ganglion nerve-cells of the posterior horns possess no axis-cylinder processes, and are in communication with the nervous network of Gerlach only by means of their minute branches.

Fig. 57.



Transverse Section of the Gray Substance of the Spinal Cord through the Middle of the Lumbar Enlargement.—On the left side of the figure groups of large cells are seen; on the right side, the course of the fibres is shown without the cells. Magnified 13 diameters. (After *J. L. Clarke.*)

In the cervical region of the cord a few ganglion-cells are found in the white columns adjoining the lateral group of multipolar cells in the anterior horns.

Ependyma of the cord.—Around the central canal of the cord the neuroglia of the gray substance becomes a little more dense than elsewhere, and the fibres of the reticulum have an arrangement peculiar to this location. They follow three main directions. Some are longitudinal, parallel with the axis of the canal; others are concentric, and a few radiate perpendicular to the surface of the canal. The radial fibres are continuous with fine processes of ciliated columnar epithelial cells which line the surface of the central canal in a single layer. In the human adult the central canal is rudimentary below the cervical region of the cord, and is not patulous. This condensation of the neuroglia at the surface of the central canal constitutes the *ependyma* of the cord. The canals and various ventricles of the brain are lined by a similar tissue which is there also known as the ependyma, and is invested by a single layer of ciliated columnar cells whose deep ends divide into processes which communicate with the neuroglia-fibres. The particular arrangement of the nerve-fibres and the nerve-cells of the cord will be described in the subsequent chapters of this work.

Cortical or gray matter of the brain.—In the cortex of the brain the gray substance presents general microscopic appearances which are peculiar to it. It seems to be arranged in several illy-defined layers, one passing almost insensibly, and by small gradations into those adjoining. Fig. 3, Plate XI., very well represents a view of the cortex of the human cerebrum as it appears when ordinarily prepared for examination, but Fig. 58 gives a more intelligible diagrammatic sketch of the minute anatomy of the gray matter covering a cerebral convolution. According to Meynert, "speaking generally, the cortex presents five laminæ (see Fig. 58). The first or superficial lamina (1) is principally composed of an evenly punctated non-nervous matrix, with a few small stellate cells, and near its surface numerous fine varicose nerve-fibres decussating in all directions. The second (2) is a layer of close-set, small pyramidal corpuscles. The third (3) is a layer of large pyramidal corpuscles. The fourth (4) is a layer of small, close-set, irregular-shaped cor-

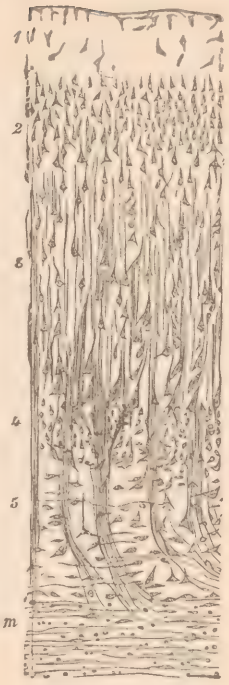
puscles; and the fifth (5) is a layer of fusiform corpuscles.

"The different parts of the same hemisphere are connected, first, by the numerous intercommunicating processes of the cells, and second, by a system of arcuate-fibres (*m*, Fig. 58) of different lengths lying immediately inside the cortex."

Lockhart Clarke differs somewhat from Meynert in his description of the general cortex of the cerebrum. He recognizes *seven* layers, and describes them as follows:—

"Most of the convolutions, when properly examined, may be seen to consist of at least *seven* distinct and concentric layers of nervous substance, which are alternately paler and darker from the circumference to the centre. The laminated structure is most strongly marked at the extremity of the posterior lobe. In this situation all the nerve-cells are small, but differ considerably in shape, and are much more abundant in some layers than in others. In the *superficial* layer, which is pale, they are round, oval, fusiform, and angular, but not numerous. The *second* and darker layer is densely crowded with cells of a similar kind, in company with others that are pyriform and pyramidal, and lie with their tapering ends either towards the surface or parallel with it, in connection with fibres which run in corresponding directions. The broader ends of the pyramidal cells give off two, three, four, or more processes, which run partly through the white axis of the convolution, and in part horizontally along the plane of the layer, to be continuous, like those at the opposite ends of the cells, with nerve-fibres running in different directions. The *third* layer is of a much paler color. It is crossed, however, at right angles by narrow and elongated groups of small cells and nuclei of the same general appearance as those of the preceding layer. These groups are separated from each other by bundles of fibres, radiating towards the surface from the central white axis of the convolution, and together with them form a beautiful fanlike structure. The *fourth* layer also contains elongated groups of small cells and nuclei, radiating at right angles to its plane; but the groups are broader, more regular, and, together with the bundles of fibres between them, present a more distinctly fanlike structure. The *fifth* layer is again paler and somewhat white. It contains, however, cells and nuclei which have a general resemblance to those of the preceding layers, but they exhibit only a faintly radiating arrangement. The *sixth* and most internal layer is reddish gray. It not only abounds in cells like those already described, but contains others that are rather larger. It is only here and there the cells are collected into elongated groups, which give the appearance of radiations. On its under side it gradually blends with the central white axis of the convolution, into which its cells are scattered for some distance.

Fig. 58.



Transparent Section of a Furrow of the Third Central Convolution of Man. Moderately magnified. 1. Layer of scattered small cortical corpuscles. 2. Layer of close-set, small, pyramidal, cortical corpuscles. 3. Layer of large pyramidal corpuscles. 4. Layer of small, close-set, irregularly shaped, cortical corpuscles (granule-like formations). 5. Layer of fusiform cortical corpuscles. *m*. Medullary layer. (*Meynert.*)

"The *seventh* layer is the central white stem or axis of the convolution. On every side it gives off bundles of fibres, which diverge in all directions, and in a fanlike manner towards the surface, through the several gray layers. As they pass between the elongated and radiating groups of cells in the inner gray layers, some of them become continuous with the processes of the cells in the same section or plane, but others bend round and run horizontally, both in a transverse and longitudinal direction (in reference to the course of the entire convolution), and with various degrees of obliquity. While the bundles themselves are by this means reduced in size, their component fibres become finer in proportion as they traverse the layers towards the surface, in consequence, apparently, of branches which they give off to be connected with cells in their course. Those which reach the outer gray layer are reduced to the finest dimensions, and form a close network with which the nuclei and cells are in connection.

"Besides these fibres which diverge from the central white axis of the convolution, another set, springing from the same source, converge or rather curve inwards from opposite sides, to form arches along some of the gray layers. These arciform fibres run in different planes—transversely, obliquely, and longitudinally—and appear to be partly continuous with those of the diverging set which bend round, as already stated, to follow a similar course. All these fibres establish an infinite number of communications in every direction, between different parts of each convolution, between different convolutions, and between these and the central white substance."

The cerebro-spinal nerve-centres are enveloped by

membranous structures, which will be especially considered hereafter. They carry the blood and lymph to and from the nervous tissue. In the white and gray substance of the cerebro-spinal centres, the bloodvessels of all sizes run in lymph-channels. The blood-capillaries of the brain are some of the smallest in the whole organism. The capillary vessels are much more numerous in the gray than in the white substance.

SPINAL NERVE-GANGLIA.

As is well known, the sensory roots of the spinal nerves pass through a collection of ganglion nerve-cells before uniting with the anterior roots to form a nerve of double function. In leaving the spinal marrow, and passing out of the spinal canal, the nerves perforate the frail envelope of the cord without receiving any part of it as a covering. In penetrating the arachnoidal and the dural investment of the cord, however, the roots of the spinal nerves receive fibres from each of these membranes, and are consequently surrounded by an inner or arachnoidal and an outer or dural sheath, which form respectively a subarachnoid and a subdural lymph-space around the nerve-root, each entirely separated from the other; but communicating freely with the corresponding space of the spinal cord. As the nerve-roots pass on and unite to form the spinal nerve, the dural sheath becomes continuous with, and is represented by, the epineurium, while the arachnoid is represented by the perineurium.

The spinal ganglia are enveloped in fibrous tissue arranged in a manner quite analogous to that of the nerves. Groups of ganglion-cells are surrounded by a laminated connective-tissue identical in structure and continuous with the perineurium of the nerve-bundles. The ganglion is composed of a larger or smaller number of such groups separated and held together by a loose, tough connective-tissue in which small arteries and veins ramify. This represents the epineurium of the nerves, and is continuous with it. The ganglion-cells constituting a group are separated from each other by a variable amount of delicate, loose connective-tissue very similar to the endoneurium separating the individual fibres of the nerve-bundles which penetrate between the ganglion-cells of a group. In this endoneurium capillary blood-vessels course, and single nerve-fibres or groups of medullated and non-medullated fibres run between the ganglion-cells.

Ganglion-cells.—The *ganglion nerve-cells* are comparatively large, and of divers sizes and forms. The prevalent form is that of an oval or somewhat pear-shaped body, with one, rarely two or more processes. This large nerve-cell contains one large spherical, generally excentric, nucleus, containing one or more refractile nucleoli. The nucleus is enveloped in a

EXPLANATION OF PLATE XI.

Fig. 1. Represents half of a transverse section of the spinal cord of Man in the lumbar region. Very slight enlargement.

f, The anterior median fissure; *f'*, the posterior median fissure; *d*, the remains of the central canal lined with columnar epithelium, and located in the gray commissure. In front of the latter is seen the decussation of the white fibres of the commissure; *c*, the anterior horn of the gray matter; *a*, bands of nerve-fibres issuing from the anterior horn to form the anterior root of a spinal nerve; *b*, posterior root issuing in a single band from the gray matter of the posterior horn; *m*, the lateral tract; *t*, the posterior radical tract; *g*, the column of Goll; the fibres of the two latter together form the posterior column.

Fig. 2. Transverse section of a portion of the external anterior border of the gray matter of an anterior horn of the spinal cord of Man. Highly magnified.

c, Cross-sections of medullated nerve-fibres of the adjoining white substance; *a*, nuclei of the neuroglia of the gray matter; *n*, *n*, nerve-fibres running in the gray matter; a multipolar ganglion-cell, finely striated, is seen imbedded in the gray substance; within the ganglion-cell a large vesicular nucleus containing a nucleolus is distinctly visible.

Fig. 3. Vertical section of the cortex of a cerebral convolution of Man. Medium enlargement.

a, Cortical layer in which the prevalent direction of the connective-tissue or neuroglia-fibres is parallel to the surface; *b*, layer of small club-shaped nerve-cells; *g*, layer of larger club-shaped nerve-cells; *c*, capillary bloodvessels.

Fig. 4. A surface view of a fibrous lamella of the cornea after treatment with silver nitrate. High power.

l, *s*, Lymph-spaces; *n*, a corneal nerve-bundle ensheathed in a covering of endothelial cell-plates.



Fig 2

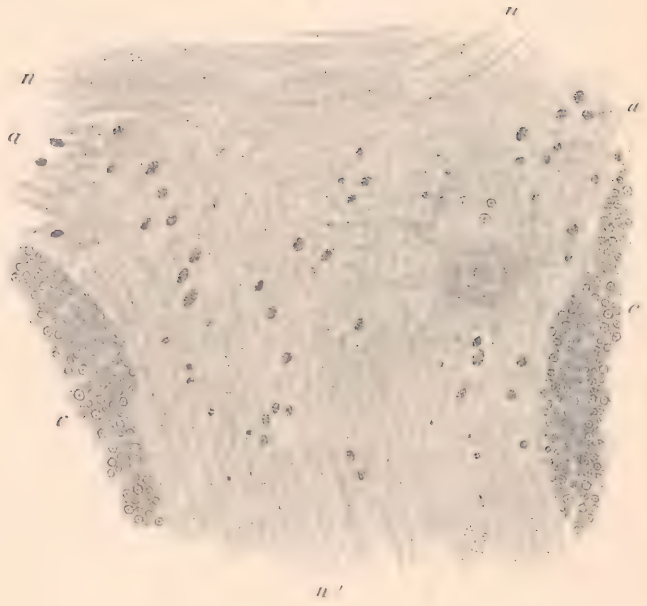
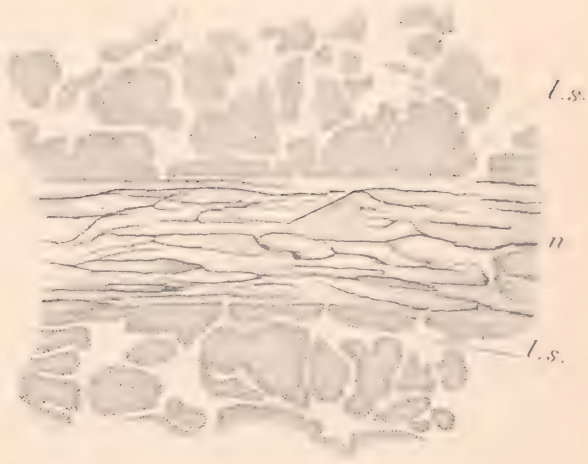


Fig 3



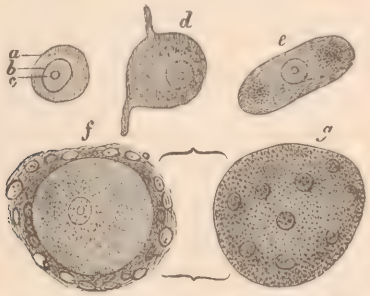
Fig 4.



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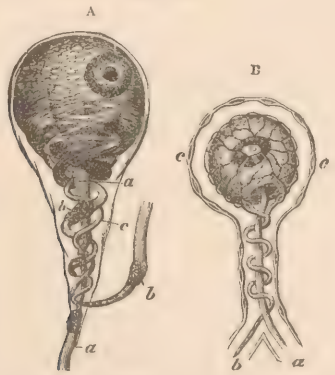
double-contoured membrane, and contains an intra-nuclear network, in communication with an intra-cellular network in the body of the cell. This intra-cellular network continues into the process. The latter may be regarded as an *axis-cylinder process*. The ganglion-cell is enveloped by a thin homogeneous membrane or capsule, which is continuous with the neurilemma or sheath of Schwann of the nerve-fibre with which it is connected. The enveloping membrane of the ganglion-cell is lined by granular, flattened, somewhat polyhedral cells. They are analogous with the nerve-corpuscles of the medullary sheath of a nerve. The ganglion-cell usually fills the space formed by the enveloping membrane. It frequently contains a small number of yellowish or dark-brown pigment-granules in some portions of the cell-body. Instead of the ganglion-cell being unipolar, it may be bipolar or even multipolar.

Fig. 59.



Nerve-Cells from the Gasserian Ganglion of the Human Subject.—*a*. A globular one with defined border. *b*. Its nucleus. *c*. Its nucleolus. *d*. Caudate cell. *e*. Elongated cell with two groups of pigment-particles. *f*. Cell surrounded by its sheath or capsule of nucleated bodies. *g*. The same, the sheath only being in focus. Magnified 300 diameters. (*Gray*.)

Fig. 60.



Structure of Ganglionic Nerve-Cell.—A. According to Dr. Beale: *a*, straight process; *c*, spinal fibre. B. According to Arnold. Highly magnified.

A, Fig. 60, represents, according to Beale, a peculiar form of bipolar glanglion-cell not infrequently found in the spinal ganglia of frogs, and occasionally met with among mammals. It differs from the last-described unipolar cells by having, in addition to a straight axis-cylinder process similar to that of the common unipolar cell, a smaller branch which winds more or less spirally around the larger straight process until it has passed a little distance from the body of the cell, when it leaves the straight process and turns to pursue an opposite direction. The spiral turns are entirely within the common membranous envelope of the cell. The straight process proceeds on its course without acquiring a medullary sheath, while the spiral-fibre soon becomes ensheathed in a medullary cylinder. Within the ganglia the nerve-fibres arising from the ganglion-cells are generally gray, gelatinous fibres without a medullary sheath; the latter, nevertheless, they may or may not subsequently acquire. The bundles of nerve-fibres which pass into a group of ganglion-cells spread out and wind around among the cells to emerge again after losing some fibres and gaining others, ultimately to end in their final distributions.

SYMPATHETIC NERVE-GANGLIA.

The larger ganglia of the sympathetic nervous system do not essentially differ from the spinal ganglia, either in their general plan of construction or in the character of their ganglion-cells. They need not be more particularly mentioned here.

Fig. 61.

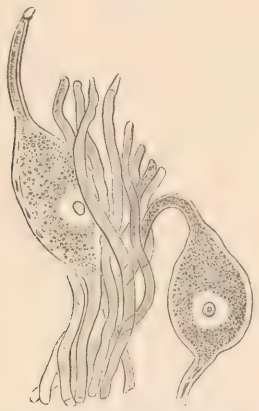


Microscopic Ganglion from Heart of the Frog. (*Stricker*.)

Along the course of the sympathetic nerves are found single ganglionic cells and isolated small groups of cells, constituting simple *microscopic ganglia*. These microscopic ganglia and isolated ganglion-cells are of quite frequent occurrence in the nervous plexuses supplying involuntary muscles, as, for instance, the unstriped muscles of the intestine, the walls of blood-vessels, and the heart. The ganglion-cells are usually located at or near the nodal points of the nervous network, the larger groups being found in the ground-plexus, or compound bundles of non-medullated free

axis-cylinders contained within a delicate perineural sheath. The cells are within the perineurium and among the nerve-fibrils with some of which they are continuous. The smallest groups and isolated cells

Fig. 62.



Bipolar Ganglionic Cells and Nerve-fibres from the Ganglion of Fifth Pair in the Lamprey. (*Frey.*)

are also sometimes situated in the ground-plexus, but they are frequently located at the nodal points of the smaller compound bundles of free axis-cylinders. These ganglion-cells are found to present the same general characters as those of the large sympathetic ganglia, and need not be more particularly dwelt upon. They are very frequently loaded with dark pigment-granules.

THE LYMPHATIC SYSTEM.

The lymphatic is the most extensive system of the organism, and one of the most important. It is mainly by the way of the lymph that the nutritive supply from the blood ultimately reaches the morphological elements of the tissues, for only a very small proportion of the latter are brought into direct contact with the blood-capillaries. There is a constant exudation of the fluids of the blood through the delicate walls of its vessels into the neighboring lymph-spaces, and there is an incessant flow from the latter towards the collecting trunks of the lymphatic system. It is entirely by the overflow from the blood that the tissues of the body are irrigated. In comparison to the velocity of the blood, the lymph-current is extremely sluggish. It is impelled principally by a *vis à tergo*—the slow oozing from the blood-vessels caused by the centrifugal pressure upon their walls through the impetuous rush of the blood-torrent. It is aided by the pressure of surrounding parts in movement, and to some extent also by the action of muscle-fibres which sometimes appertain to the lymphatic system. This broad though sluggish stream has been very aptly denominated a supplement of the blood-circulation.

The lymph flows in channels which are variously related to each other, and to the different components of the organism. Their structure and their relations to each other will be first considered.

The lymph-passages comprise large and small trunks, into which capillaries empty, and which, in their turn, receive lymph from the adjacent interstices of the tissues, the latter being either small lymph-spaces, as the lymph canalicular system of von Recklinghausen, or large lymph-cavities like the peritoneal, the pleural, the pericardial, the arachnoid, etc. Along the course of the lymph-current are interposed numerous aggregations of a peculiar *reticular tissue.* The most complex arrangement of this peculiar tissue into special organs is found in the so-called compound lymphatic glands, such as those of the axilla, the groin, the mesentery.

Large lymph-vessels.—The *largest lymphatic trunks* consist of a wall of some thickness and complexity of structure. This wall is very similar to that of veins. It is composed of three coats—an external, middle, and internal, which are respectively known as the tunica adventitia, the tunica media, the tunica intima. The internal coat is very thin and delicate, consisting of an inner layer of endothelial plates similar to those of veins; of an external layer of longitudinal connective fibres and a few elastic fibres; and of a middle layer of a few stellate, flattened corpuscles. The tunica media contains a few circular, smooth muscular fibres. The tunica adventitia is composed of a feeble network, mainly longitudinal, of fibrous bundles interspersed with a few elastic fibres, also united into a network. Vasa vasorum and nervæ vasorum run in the tunica adventitia, and ramify in the tunica media.

Small lymph-vessels.—The *smaller trunks* have extremely delicate walls; the latter are reduced to a simple endothelial lining of the lymph-channel. By their wall simply they are often not distinguishable from the lymph-capillaries. When empty, in consequence of the flabbiness of their walls, they are completely collapsed, and their cross-section appears as a mere slit in the tissues. When distended, these smaller lymphatic trunks are more or less cylindrical in form.

Valves.—Lymphatic trunks are distinguished by the presence of valves at frequent intervals. The valves often constitute the only distinction between

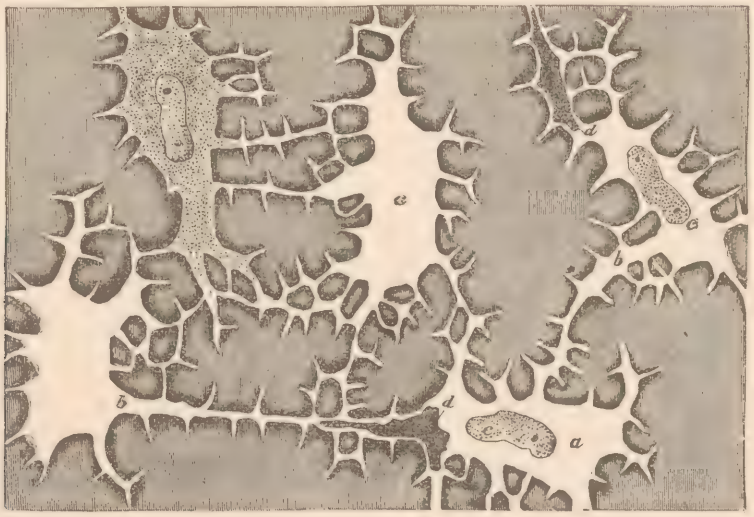
small trunks and capillaries. They consist of folds of the tunica intima projecting into the lumen of the vessel, usually in the shape of two hemispherical sacs, which rest lightly against the wall of the vessel, except when the lymph attempts to flow backwards. Then they project into the lumen until the opposite sacks meet and form a kind of lymph-sac. At the location of these valves there is a slight bulging outward of the lymphatic walls. Such ampullar enlargements along the lymphatic trunks are very prominent when the vessels have been artificially injected. In the small lymph-trunks the lining endothelia usually have somewhat the outline of a long lozenge, with slightly sinuous edges. The smaller lymph-trunks sometimes anastomose with each other, and form a plexus.

Lymph-capillaries.—The small lymphatic trunks communicate with plexuses of *lymph-capillaries*. Lymph-capillaries are channels through the tissues, with walls possessing a simple endothelial lining of broad, sinuous-edged cells, and with outlines extremely varied. Their lumen, even when full, may be oval, slit-like, ampullar, or jagged. Unlike the capillary bloodvessels, which they enormously exceed in size (fig. 3, Plate VII.), they are frequently larger than the trunks into which they empty. Their general direction and their form are very considerably influenced by the arrangement of the tissues among which they lie.

Until the investigations of von Recklinghausen, Klein, Axel Key, Retzius, and others, in recent years threw a flood of light upon the subject, lymph-capillaries were considered to be the ultimate ramifications of the lymphatic system.

Lymph-canalicular system.—Von Recklinghausen demonstrated a connection between the small irregular plasmatic spaces, existing in the albuminoid, semi-fluid cement, in which the connective-tissue fibres are imbedded, and the lymphatic capillaries. These irregular spaces, with their canalicular branches and the connective-tissue cells which they frequently contain, von Recklinghausen described as a *lymph-canalicular system* (Fig. 63), and recognized as the ultimate radicles of the lymphatic vessels. By their branching canaliculi these lymph-spaces intercommunicate with one another, and those nearest the lymph-capillary open into the latter. These minute lymph-spaces among the tissues normally may contain, as we have already seen, one or more flattened connective-tissue corpuscles usually applied to one side of the space. They have no other endothelial lining. In those spaces directly communicating with a lymph-capillary, the connective-tissue corpuscle, by one of its processes, is often continuous with an endothelial plate lining the capillary. The point of communication of a lymph-canaliculus with the lumen of a lymph-capillary corresponds to an opening between the edges of the endothelium—a *stoma*. The lymph-spaces are of extremely variable size and form. Sometimes stellate, sometimes slit-shaped, sometimes more or less cylindrical, they are moulded by the direction of the fibrous bundles, membranes, or other tissues in which they are imbedded. There are in different portions of the body all gradations in size and form

Fig. 63.



CORNEA OF THE FROG TREATED WITH LUNAR CAUSTIC, highly magnified.—*a*. Canalicular systems. In one place a branched flattened corneal corpuscle with its nucleus is seen; in two other places nuclei, *c*, of corneal corpuscles, and, *d*, migrating or wandering cells, are seen in the lacunæ of the canalicular system. *b*. Branched channels, which connect the lacunæ of the canalicular system. (*Carpenter.*)

between minute, more or less stellate lymph-spaces and genuine large lymph-cavities, whose surfaces are covered with a complete endothelial lining. Slit-like spaces are frequently found, particularly in laminated fibrous membranes, lined only on one side with a complete endothelial layer.

Relations of the lymph-canalicular system with lymph-capillaries and serous cavities.—The serous cavities have already been described. They are, on the one hand, in communication with the lymph-spaces or lymph-canalicular system adjoining them, and, on the other hand, through the mediation of lymph-capillaries, are directly continuous with lymphatic trunks. Von Recklinghausen first demonstrated the communication between the cavity of the peritoneum and lymphatic trunks of the diaphragm, but we owe our most positive knowledge of the anatomy of the lymphatic system of the abdominal and thoracic cavities to the valuable and painstaking labor of Klein.

According to Klein, the peritoneal surface of the centrum tendineum of the diaphragm is covered by an endothelial lining, whose cells have not all the same character and arrangement. The great majority of the endothelia are ordinary, thin, elastic cell-plates, with slightly sinuous outlines, and flat, oval nuclei. At intervals over this surface are clumps of smaller, polyhedral granular cells (*germinating endothelia*), with sometimes two and even a greater number of nuclei. These small collections of germinating endothelia surround a small hole in the serous surface. The holes are known as *true stomata*, in contradistinction to certain small groups of similar germinating endothelia (*pseudo-stomata*) in which no hole is apparent (fig. 1, Plate I.). The centrum tendineum consists of two general layers of fibrous bundles. In the lower, or peritoneal layer, the bundles have a direction radiating from the centre of the aponeurosis. In the upper, or pleural layer, the fibrous bundles are concentric. Between the fibrous bundles of each of these aponeurotic layers is a system of lymph-capillaries. Their main direction is, of course, the same as that of the fibrous bundles between which they run. The capillaries of the same layer occasionally anastomose with their neighbors by lateral branches, and the two systems also intercommunicate by vertical canals running from one layer to the other. Now, the above-mentioned *stomata vera* are located upon the peritoneal surface, over the spaces between the radiating fibrous bundles of the lower layer. They open into superficial, small, vertical canals, which lead into the nearest lymphatic capillaries. Upon the pleural surface of the diaphragm, over the interspaces between the concentric fibrous bundles of the upper aponeurotic layer, are also numbers of *stomata vera*. These latter open by short vertical lymph-channels into a superficial plexus of lymphatic trunks between the basement-membrane of the diaphragmatic pleura and the centrum tendineum. This superficial plexus of lymphatic trunks is provided with numerous valves. It is in communication below with the lymphatic capillaries of the upper layer of the tendon of the diaphragm, and, as a consequence, with the cavity of the peritoneum. The lymph which reaches the subpleural plexus of lymphatic trunks is conducted by two different ways into the general circulation. Over the anterior two-thirds of the upper surface of the diaphragm, the lymph is drained off by two main trunks, one for each side, which pass forward to the anterior wall of the chest, and ascend behind the sternum as far as the manubrium, where each enters a lymphatic gland. The lymph of the posterior third of the above plexus is conveyed by means of two main short trunks directly into the thoracic duct. The movements of respiration cause this diaphragmatic system of lymphatics to act somewhat as a pump in draining the peritoneal cavity.

Lymphatic system of muscles.—In the aponeurotic sheath of muscles it has been found that the inner and outer layers each possess a system of lymph-capillaries which bear much the same relation to each other as do those of the diaphragm. The outer plexus of lymphatic capillaries is drained by lymph-trunks with numerous valves. The lymph-capillaries and lymph-spaces of the endomysium are in communication, on the one hand, with the lymph-cylinders surrounding the ultimate or primary muscle-fibre, and, on the other hand, with the lymph-passages of the perimysium.

Communications of the cerebro-spinal cavities.—The large serous cavities of the cerebro-spinal axis have various ramifications and connections. The space between the encephalon and the inner surface of the dura mater is a double serous cavity. The one part of this cavity is separated from the other by a delicate partition—the arachnoid. The space between the dura mater and the arachnoid has been termed the *subdural cavity;* while that between the arachnoid and the intima pia has been named the *subarachnoid cavity* of the cranium. It is claimed that the one has no communication with the other. Some authors recognize also a third general lymph-space existing between the pia mater and the cerebral substance.

Between the coverings of the spinal cord there are also corresponding lymph-cavities, which are separated from each other by the arachnoid, namely, the subdural and the subarachnoid cavities of the cord. They freely communicate with the corresponding cavities of the brain. The external surface of the dura is covered with endothelium, as are also the surfaces of the large lymph-spaces of the cerebro-spinal nervous system.

The subarachnoid cavity of the brain communicates with the ventricles of the cerebrum. The bloodvessels from the arachnoid pass through the pia into the brain, taking a lamina of the arachnoid with them as a sheath (the perivascular sheath), the lymph-spaces of which are in communication with the subarachnoid space. The perivascular sheath of the smallest vessels is a simple layer of endothelium, partially lining a perivascular lymph-channel, whose wall is simply the surrounding neuroglia. The lymph leaks out through this porous wall and percolates among the minute meshes of the neuroglia-fibres to reach the *pericellular lymph-spaces* surrounding the ganglion-cells of the gray substance and the *peri-fibrillar lymph-spaces* existing between the neuroglia and the bare medullated nerve-fibres of the white substance. In this manner the ganglion-cells and the nerve-fibres of the cerebrum are brought into communication with the subarachnoid lymph-cavity of the cerebrum.

An essentially similar arrangement of the lymph-circulation exists in the spinal cord.

Lymphatics of the spinal nerves.—While considering the minute anatomy of the spinal ganglia, occasion was taken to refer to the continuation of the subdural and subarachnoid cavities of the cord into the spinal nerves: the subarachnoid being continuous with the perineural lymph-space of the nerve; the subdural communicating with the epineural lymph-spaces. The endoneurium between the individual nerve-fibres contains lymph which on one side communicates with spaces around the nerve-fibres—on the other with the subperineural space. The cranial nerves have a lymph-circulation similar to that of the spinal nerves. In the spinal ganglia the epineural and the perineural lymph-spaces communicate with corresponding spaces of the cord and of the nerve to which they are attached.

Lymphatics of bloodvessels.—The bloodvessels of large size generally possess two systems of lymphatics—one for the tunica intima and one for the two outer tunics. Fig. 2, Plate XII., represents the lymph-canalicular system of the middle or connective-tissue layer of the tunica intima of a large arterial trunk. The tunica adventitia is pre-eminently a trabeculated peri-vascular lymph-space which is in free communication with lymph-spaces scattered through the tunica media. Besides the lymph-spaces in the tunica adventitia, the vessel may be partially or completely ensheathed by a perivascular lymph-space (fig. 1, Plate XII.), or be surrounded by a dense plexus of lymph-vessels.

These perivascular lymphatics frequently communicate with the lymph-canalicular system of the tissue through which they pass. Fig. 1, Plate XII., shows a capillary bloodvessel having such a relation to the lymph-spaces of the surrounding tissue. A, fig. 3, Plate XII., is a faithful reproduction of a small branch of a pulmonary artery, *a*, and an accompanying lymphatic capillary, *b*, which communicates with the lymph-canalicular spaces, *c*, in the inter-alveolar septa. B, same figure, gives a surface view of the inter-alveolar lymph-spaces.

Lymphatics of bones.—In bones the lymph-canalicular system is represented by the bone-corpuscles. By their canaliculi, these lymph-spaces freely open into the lymphatic capillaries of the Haversian canals. The Haversian lymph-vessels accompany or more or less completely ensheathe, as perivascular lymphatics, the bloodvessels of these canals, and in their turn communicate with the lymph-vessels of the periosteum.

Lymphatics of cartilages.—Cartilage also possesses a canalicular lymphatic system which directly empties into the lymphatics of the perichondrium. The expansions of the lymph-canalicular system of cartilage are the cartilage capsules.

Lymphatics of epithelial structures.—Not only is the lymph-canalicular system of von Recklinghausen in direct open communication with lymph-canals and cavities as above stated, but, according to Thoma, Arnold, and others, the intercellular cement between the epithelia of the skin, mucous membranes, and glands, and between the endothelia lining the lumen of bloodvessels, is often continuous with the contents of neighboring lymph-spaces, and should in such cases be regarded as a projection of the lymph-canalicular system. In this intercellular cement, circulation is generally very slow, but nevertheless quite manifest. It is through these channels that minute solid particles enter the submucous lymphatics of the air-passages and the interalveolar lymph-spaces of the air-vesicles of the lungs. The probability that the minute molecules of the chyle reach the capillary lacteals of the villi in a similar manner, and that for-

eign particles injected into the blood pass out between the cells of the excreting glands, has already been alluded to.

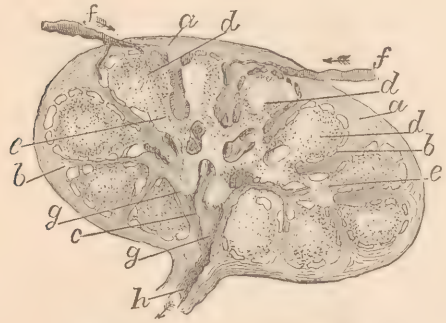
LYMPHATIC GLANDS.

Lymph-glands and allied reticular or lymphoid tissues, important parts of the great lymphatic system, yet remain to be considered.

Lymph-glands are more or less complex organs implanted in the course of lymphatic trunks, and apparently designed for the elaboration of some of the colorless elements of the lymph. They may consist of simple isolated lymph-follicles, or of an aggregation of them. Since a large lymph-gland is practically nothing more than a peculiarly-arranged aggregation of simple lymph-follicles, a single description must here suffice.

Lymph-glands, such as those of the axilla or mesentery, are more or less ovoid in shape. They are

Fig. 64.



SECTION OF SMALL LYMPHATIC GLAND, HALF DIAGRAMMATICALLY GIVEN, WITH THE COURSE OF THE LYMPH.—*a*. The envelope. *b*. Septa between the follicles or alveoli of the cortical part. *c*. System of septa of the medullary portion, down to the hilus. *d*. The follicles. *e*. Lymph-cords of the medullary mass. *f*. Afferent lymph-vessels, the different lymphatic streams from which surround the follicles, and flow through the interstices of the medullary portion. *g*. Confluence of these to pass through the efferent vessel (*h*) at the hilus. (*Frey*.)

enveloped by a capsule (Fig. 64), which generally consists of two layers: an outer layer of loose connective-tissue, and an inner lamellated layer of dense fibrous tissue. Among the fibrous bundles of these two layers are, in some animals, a variable number of smooth muscle-fibres. Upon one side of the gland two or more large lymphatic trunks, which convey the lymph to the gland (*afferent vessels*), enter the outer layer of the capsule and ramify therein to form a dense plexus. The afferent trunks are supplied with circular muscular fibres in their middle tunic, and with numerous valves. At the opposite side or hilus of the gland a number of small vessels unite to form a large trunk which receives the lymph from the gland and conveys it off (*the efferent vessel*). Upon examination of longitudinal section of the gland made from the convex surface towards the hilus, the section appears unevenly colored and somewhat mottled. The central third is of a deeper red, and seems more homogeneous, while the outer border is lighter colored and is mottled. The inner is the *medullary*, the outer is the *cortical* portion of the gland. The minute anatomy of the organ is somewhat different in these two regions. From the inner surface of the dense lamellated inner layer of the capsule, membranous partitions or septa (*b*, Fig. 64) project inwards in such a manner as to form in the cortical layer a series of honeycomb-like compartments, which, in consequence of the fact that the dividing septa converge towards the centre of the gland, are more or less conical with the bases outward. When these septa reach the medullary area, they break up into a large number of thinner or thicker bands or *trabeculæ*, which branch and anastomose with one another so as to form a loose, sponge-like network. The meshes of this medullary inter-trabecular network communicate with each other and with the conical compartment of the cortical layer. The membranous septa between these compartments are often incomplete.

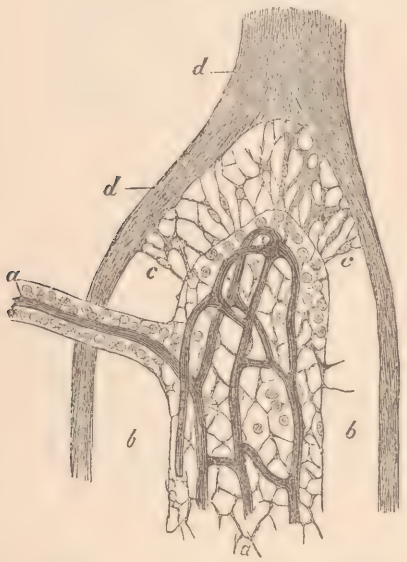
The conical compartments of the cortical, or *follicular layer*, as it has been called, are more or less completely filled by a pear-shaped cellular mass, the so-called *follicle* (*d*, Fig. 64). At the border of the medullary portion of the gland this cellular mass tapers down to a narrow stem, which passes into the intertrabecular spaces, and becomes a *medullary cylinder*, or cord (*e*, Fig. 64). In the medullary portion of the gland the medullary cylinders branch and anastomose in a complex manner to form an irregular network of cellular cylinders.

The cortical follicles and the medullary cylinders consist of a reticular or adenoid tissue permeated by a rich network of blood-capillaries. They do not entirely fill the spaces in which they lie, but are separated from the septa of the cortex, and the trabeculæ of the medullary portion by a lymph-sinus of considerable size. The lymph-sinuses surrounding the cortical follicles are continuous with those which surround the medullary cylinders. The afferent lymph-vessels ramifying in the capsule, as above described, penetrate the inner laminated layer of the capsule and open freely into the cortical lymph-sinuses. The efferent lymphatic trunks (*g*, *h*, Fig. 64) of the hilus directly communicate with the lymph-sinuses enveloping the medullary cylinders. The free course of the lymph is, therefore, from the afferent vessels of the capsule into the cortical peri-

follicular sinuses, thence through the medullary sinuses into the collecting trunks which empty into the efferent vessels emerging from the hilus.

The flow of the lymph through these sinuses is greatly impeded by innumerable fine fibres united into a network which crosses the space from the follicles to the septa in the cortical region, and from the medullary cylinders to the trabeculæ in the medullary portion (*c*, Fig. 65). The fibres of this

Fig. 65.



Portion of the Medullary Substance of the Mesenteric Gland of an Ox.—The artery injected with chromate of lead. Highly magnified. *a*. Medullary cylinder with capillary network, fine reticulum of connective-tissue, and a few lymph-corpuscles. *b*, *b*. Superficial lymph-path or medullary sinus traversed everywhere by a reticulum of nucleated cells. This reticulum has been represented only at *c*, with numerous anastomosing prolongations. The lymph-corpuscles have for the most part been removed with a camel's-hair brush. *d*, *d*. Trabeculæ, composed almost exclusively of unstriped muscular tissue. A small medullary cord or bridge, containing a bloodvessel and numerous lymph-corpuscles, is shown at the left of the figure as springing from the medullary cylinder. (*Stricker*.)

reticulum are hyaline, and present every variation in shape from the flattened band to the cylinder. At their nodal points they slightly enlarge, and very frequently a flattened oval nucleus is seen at these enlargements. The reticulum consequently appears to be formed by a network of large stellate cells resembling branched connective-tissue corpuscles. But in the adult tissue this is an illusion. The nuclei belong to flat endothelial plates which closely invest the fibres of the reticulum. Every part of the surface of the lymph-sinuses above described is lined with a complete layer of endothelial plates. They cover the reticular partitions as well as the septa and trabeculæ on the one side, and the surface of the follicles and cylinders on the other.

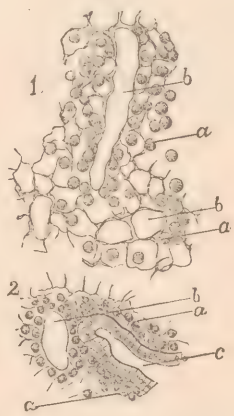
Each of the coarse meshes of this reticulum in the lymph-sinus contains two or more lymph corpuscles which quite fill it.

The cortical follicles and the medullary cylinders have the same constitution. They consist of a reticulum of a construction very similar to that of the lymph-sinuses. But the fibres which form it are very much more delicate, and the meshes are much smaller. At some of the nodal points of this reticulum a flattened ovoid nucleus may be seen. As in the former case, these flattened nuclei belong to endothelial plates resting upon the fibres. In the follicles and cylinders, however, the surfaces of the reticulum are not completely covered with endothelial cells. The small meshes of this reticulum are closely packed with one, two, or more lymph-corpuscles which are usually of the smallest size, consisting of a large round nucleus surrounded by a minimum amount of cell-protoplasm. They are supposed to be young developing lymph-cells.

The fine reticulum of the follicles and cylinders is permeated by a rich network of capillary blood-vessels (Fig. 65). The walls of these capillaries are enveloped by and connected with the fibres of the reticulum (fig. 6, Plate VI.).

Besides a lymph-current in the sinuses from the afferent towards the efferent vessels, there is also a current in the follicles and cylinders setting outwards from the blood-capillaries towards the surrounding perifollicular and pericylindrical sinuses. The latter current, aided by the amœboid movements of the cells, washes the lymph-corpuscles from the follicles

Fig. 66.



1. Reticular Tissue, from a lymphoid follicle of the vermiform appendix of the rabbit, with the system of meshes, and remains of the lymph-cells *a*. Most of the latter have been removed artificially. *b*. Lymph-vessel. 2. Longitudinal section of a Lieberkühn's gland, showing the surrounding reticular tissue. In the meshes of this are seen the lymph-cells *a*. *b*. Lumen of a vessel. *c*. Lumen of the gland. (*Frey*.)

and cylinders out into the surrounding sinuses, and the current in the latter finally carries the cells into

the efferent vessels. The meshes of the reticulum of the sinuses, and especially those of the follicles and cylinders, are so packed with lymph-corpuscles that, in sections ordinarily prepared, nothing can be seen but the crowd of cells. In order that the reticula may become visible, it is necessary to gently pencil the sections with a camel's-hair brush or to persistently shake them in a fluid medium. When this procedure is successful, a thin section of the medullary portions presents a picture very well reproduced in Fig. 66.

The arterioles and venules which communicate with the capillaries of this tissue run in the septa and trabeculæ.

Reticular tissue (adenoid tissue of His) is a lymphoid tissue which has its perfect type in the structure of the follicles and medullary cylinders of lymph-glands. It is, therefore, unnecessary to describe it more particularly in this place. It is present in a diffuse form in the mucous membrane of the intestine and of other localities. It is met with in serous cavities in the form of patches and cords of variable extent, and it is found in numerous other localities.

EXPLANATION OF PLATE XII.

Fig. 1. A silver preparation of a pencilled omentum of a Rabbit, showing relations of blood- and lymph-vessels. High power. (After Klein.)

v, A venule filled with blood-corpuscles; the venule gives off capillary branches; *l*, lymphatic capillary, invaginating the bloodvessels, and lined with endothelium, the outlines of which are mapped out by the serrated dark lines; *s'*, branches of the lymph-vessels in some places communicating with the neighboring lymph-spaces.

Fig. 2. Internal tunic of the Human aorta, treated with silver. High power. (After Langhans.)

a, Superficial lymph-spaces; *b*, deeper lymph-spaces; both freely intercommunicate, and are separated from one another by the ground-substance, *g*.

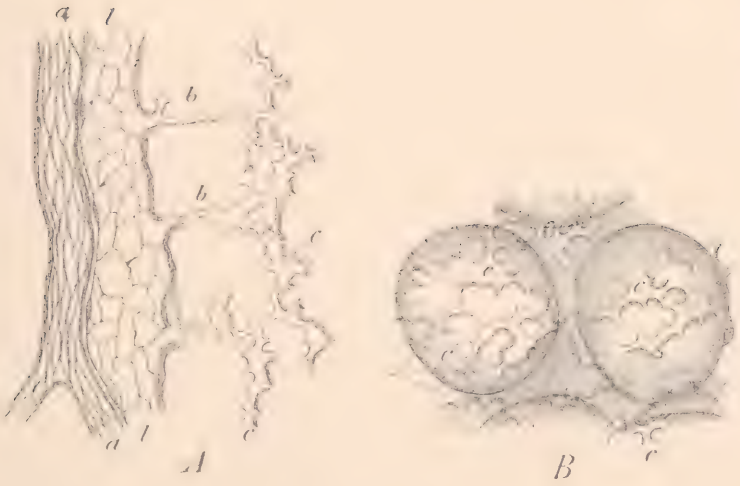
Fig. 3. *A*. From a section of a Guinea-pig's lung, which had been injected with silver nitrate, showing the relations of blood and lymph-vessels. High power.

a, Branch of pulmonary artery; *l*, lymph-vessel lined with endothelial plates, and in connection with the lymph-canalicular system or inter-alveolar lymph-spaces, *c*, of the walls of the alveoli.

B. Same lung, showing the inter-alveolar lymph-spaces, in surface. (After Klein.)







T. Sinclair & Son, lith.

ALLEN'S

HUMAN ANATOMY.

BONES AND JOINTS.

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DESCRIPTIVE ANATOMY.

THE BONES.

GENERAL CONSIDERATIONS.

THE skeleton is an assemblage of bones and cartilages joined together to form the framework of the body. Its several parts serve to protect the viscera, and to act as organs of passive locomotion.

A skeleton, as preserved in the cabinet, is said to be *natural* when the bones and cartilages are held in their natural relations by means of ligaments. It is said to be *artificial* when the ligaments have been removed, and wire and leather, or other materials, are substituted for them.

ORIGIN OF BONES.—The bones of the skeleton arise from cartilage for the most part; such are often named, from this fact, *cartilage bones*. Bones not arising from cartilage develop from fibrous tissue; such bones are known as *membrane bones*, since they for the most part appear in membranous expansions. The parietal and frontal bones belong to this group.

CARTILAGES.—The cartilages of the body, while preserving their integrity, aid in resisting shocks and maintaining elasticity. Cartilage is called *permanent* when it presents no tendency to ossification, and *temporary* when it possesses a tendency to turn into bone.

NUMBER OF BONES.—The number of bones in the body varies according to the age of the subject. The number is increased as the several temporary cartilages ossify, and is decreased as the osseous centres unite one with another. Authors do not agree as to the number of bones in the body, since the age at which the bones should be counted has never been agreed upon.

Hyrtl makes the number of bones in the skeleton 240, Leidy, 214, Ward, 206, Quain, 200, Sappey, 198.

In order that intelligent comparison may be made between the numbers above given and the number adopted for this work, the bones are enumerated with some detail in the following order:—

Spine	24
Skull	22
Small bones of the ear	6
Neck (Hyoid)	1
Ribs	24
Sternum	1
Shoulder girdle (including scapulas and clavicles)	4
Superior extremities	60
Sesamoids of same, excluding the pisiforms	4
Pelvic girdle (including the hip-bones, sacrum, and coccyx)	4
Inferior extremities (excluding the patellæ)	58
Sesamoids of lower extremities (including patellæ)	6
	214

Of these, the occipital bone, sphenoid bone, ethmoid bone, frontal bone, and bones in the skull, and the sternum, hyoid bone, vertebral column, sacrum, and coccyx are unpaired.

The study of the development of the bones will modify the above conclusions both as to number and

symmetry. It may be stated once for all that the facts given are intended to apply to the adult skeleton, and to the purposes of the physician, and not to satisfy the needs of the student of morphology.

CLASSIFICATION OF BONES.

The bones comprising the skeleton are classified either by the region of the body in which the bones occur, as those of the head, chest, extremities, etc., or by the shapes of the bones themselves, when the terms long, flat, irregular bones, etc., are used.

THE LONG BONES.—The long bones are those which resemble for the most part modified cylinders. Hence, they are often called cylindrical bones. They are prismoidal in shape, and slightly twisted. The femur or thigh-bone, the tibia or shin-bone, the fibula or clasp-bone, and the analogous bones in the arm and forearm, are good examples of the class. Long bones of a smaller kind than the foregoing are often classified as the *short* bones. Among these may be placed the clavicles or collar-bones, and the metacarpal and metatarsal bones. They are less prismoidal than the long bones proper. The phalangeal bones, which belong to the same class, are flat on one side, and thus recall the figure of a semicylinder.

Each long bone presents a *shaft* or *diaphysis*, and two *extremities*. The shaft slightly expands to join the extremities. These form the bases of two pyramids, the apices of which may be said to unite in the shaft. In the bones of a prismoidal form the sides of the prism-like figure extend into the extremities, and serve to strengthen them. The extremities of a long bone articulate with the adjacent bones, and ordinarily form what is known as *epiphyseal ends*, owing to the fact that these portions of the bones arise from distinct centres, known as the *epiphyses*. The ligaments are here attached, the muscles have insertions, and the surfaces are marked by rugosities and venous canals.

The end of the bone nearest the body is called the *proximal* end, and that farthest away the *distal* end. When an articular surface is round and convex (especially if it is on the proximal extremity), it is called the *head* of the bone. The *neck* is a contraction placed beneath the articular surface, and is apt to be the narrowest part of the bone. No muscle is inserted either upon the head or the neck of a bone.

FLAT BONES.—The flat bones are irregular and table-like, and ordinarily are passive in their function. Such, for example, are the bones of the skull which protect the brain, and those of the pelvis which protect the internal organs of generation and in part the intestines. An important flat bone, the scapula, is however active in its function.

IRREGULAR BONES.—The irregular bones are of small size, and do not preserve any constant outline. In this class are placed the bones of the carpus and tarsus, and those of the vertebral column. Some are placed in pairs, while others are median and single. They agree in function, however, since they are always found in situations where strength and a slight motion are required. They are thus admirably adapted to sustain weight and to resist shock.

The irregular bones are arranged in a single row as in the vertebral column, or in a number of rows as in the carpus and tarsus, primarily in the longitudinal direction of the limbs, but forming at the same time transverse arches of enormous strength.

SESAMOID BONES.—The sesamoid bones are so named from their resemblance to seeds. They are rounded or oblong ossifications of small size arising in the tendons of muscles, and aid these organs in maintaining accurate relations to articular surfaces. They are thus seen in muscles crossing joints, as the quadriceps femoris and flexor brevis pollicis. They ordinarily possess one or two articular facets.

WORMIAN BONES (OSSA TRIQUETRA).—The Wormian bones are tabular. They are inconstant, of variable size, and are seen nowhere but in the vertex of the skull. They belong to the group of bones here situate, and are firmly articulated with them. They are apt to be seen between the parietal and the occipital bones.

WEIGHT OF THE SKELETON—The skeleton weighs from twelve to fourteen pounds. The right side is somewhat heavier than the left.

TERMS USED IN DESCRIBING BONE.

In the description of bones a number of special terms occur, some consideration of which is necessary to a proper understanding of the text. Among those relating to distinctions among the kinds of elevations or prominences from the common surface of a bone, may be mentioned the following:—

PROCESS.—Any projection from the bone.

CONDYLE.—An articular process of bone, which is

large, and as a rule convex. Upon the tibia, the condylar surfaces are slightly concave.

TUBEROSITY.—A large rounded process.

TROCHANTER.—A tuberosity which serves for muscular attachment in positions favorable to rotatory motion.

SPINE.—A pointed process.

CREST.—A pronounced ridge-like elevation.

LINE.—An elevation less pronounced than a crest.

Every bone presents *surfaces*, *borders*, and *angles*. These terms will frequently recur in the descriptions.

Among the depressions on the general surface of the bone may be mentioned the following:—

FOSSA.—A deep saucer-shaped depression. It may be articular, as the glenoid fossa; or muscular, as the iliac fossa. A *digital depression* is a circular shallow fossa.

GROOVE or SULCUS.—A narrow elongated depression.

FURROW.—A relatively broad, shallow groove.

FISSURE.—A narrow chink. It often answers to lines of defective union between different bones. Fissures are most commonly seen in the skull.

MEATUS.—A sulcus or canal leading to parts other than those defining the meatus. The meatus of the nasal chamber is a depression on the lateral wall of the nasal chamber leading to the pharynx; the external meatus is a tubular passage made up of the squama and tympanic bone, leading to the middle ear.

SINUS.—An open cavity with a narrowed mouth lined with mucous membrane.

The FLEXOR SURFACE and the EXTENSOR SURFACE of a bone are terms often employed in the same sense as *ventral* and *dorsal*. See Definitions in Introduction, p. 20.

The openings in bone are known as—

CANALS.—When they form tubular passages into or through bones.

FORAMINA.—When they form simple openings of transmission.

PROPERTIES OF BONE.—Bone is the firmest and hardest of the tissues, enamel alone excepted, and is especially designed to combine great strength with lightness. Elasticity is one of its most conspicuous properties. The form of the bone aids in maintaining it, as in the rib and the lower jaw; but all the bones possess it in more or less degree. Bone-tissue is either *compact* or *spongy*. When *compact*, it possesses firmness to a high degree, and when *spongy*, lightness. Compact bone is best seen in the lines adapted to bear the greatest resistance and sustain the greatest weight; the spongy is best seen in places where lightness and facility of motion or delicacy of use are the purposes required. Most of the long bones are hollow, and, as already mentioned, are termed cylindrical bones. This form aids greatly in maintaining lightness without sacrificing strength, the wall of the cylinder being composed of compact bone, while the hollow space is filled with a form of fatty tissue (p. 56).

THE CANCELLI.—The extremities of a bone are, on the other hand, solid in the sense of being without a central cavity, and are composed of reticulations of minute plates and rods of bone, which are collectively termed *the cancelli*. The cancellous, or spongy tissue, as it is indifferently termed, is admirably adapted to break the jar of a sudden blow, and to prevent it from reaching the delicate central structures of the body. Each bone exhibits a special arrangement of the cancelli, the one specially adapted to its necessities, and no two bones, or, indeed, no two parts of a single bone, preserve exactly the same arrangement.

In studying cancelli it will be seen that the stoutest laminæ, and the best mechanical disposition for sustaining weight and distributing force exist in the positions where the necessities for such properties are the greatest. As a consequence, it is evident that, while a general resemblance exists between the cancelli of bones of a natural group, as, for example, those of the vertebral column, or the ends of long bones near joints which resemble one another, great contrasts are exhibited in other bones having highly specialized lines of work to perform, such as the astragalus, the calcaneum, and the femur.

Cancelli naturally arrange themselves into those of the articular epiphyses, of the muscular epiphyses, of the ossified articular cartilages, and, in the main, into pillars and laminæ of the shafts of the bones. For convenience these subdivisions are not described separately, although each should be taken up by itself in special studies of any single bone.

The physical properties of bone are capable of being modified by the peculiarities of each of the bones, and will of necessity vary in the performance of different lines of work. The petrous portion of the temporal bone is naturally hard and brittle; the tarsal and carpal bones are spongy, and not inclined to fracture. The former has no superimposed weight to sustain; the latter have important relations to bear while supporting the entire body in the erect position.

The same differences may be noted in the various parts of a single bone. The differences in the relations of the cancelli and the compact matter in this way furnish clews to the significance of delicate mouldings, curves, lines, ridges, or of the general prismoidal or tubular shape of a bone; these are, indeed, so many accessories of structure, and aid the bone in developing to the best advantage its special phases of elasticity, lightness, strength, etc. It would be going too far into the obscure subjects of teleology, the laws of heredity, or the question of primal adaptation of structure to a preconceived design, to pursue this subject further. But this much may with certainty be said, that the general properties of bones, and indirectly their shapes and special uses, are largely determined by traction, pressure, or other familiar expressions of force.[1]

When a sequestrum forms in the cancellous structure, the bone in the vicinity becomes more compact. The sequestrum itself is somewhat more compact toward the centre than toward the periphery.

Peculiarities of the Living or Fresh Bone. —A bone when examined in its living condition is covered with a membrane called the *periosteum*, which is continuous with the tendons of the muscles inserted into the bone. In a strict sense muscles are inserted into the periosteum of the bone rather than in the bone itself. In the fresh condition the periosteum can with care be raised from the bone. It is thus seen as a thin fibrous membrane of a pearly-white color and firm consistence. In inflammation of the bone the periosteum becomes greatly thickened, and can be detached with ease. The periosteum is not a simple fibrous membrane, as a superficial examination would indicate. While its outer surface is plainly fibrous, its inner surface where it lies in contact with the bone possesses bone-producing power. The importance of a knowledge of these facts in surgical practice cannot be over-estimated.

The ease with which the removal of inflamed periosteum can be accomplished explains the presence of a blood-clot between the periosteum and the bone in the course of ostitis or periostitis. It also accounts for sub-periosteal abscess, and the rapidity with which an abscess of this kind may develop. The special value of the periosteum in aiding and maintaining bone-growth being remembered, the presence of a clot of blood or a layer of pus will be seen to withhold from the bone beneath its normal supply of blood, and the shaft of the bone may die for a distance corresponding to the area of denudation. In this way necrosis of the shaft of bones is explained.

A knowledge of the above conditions enables the surgeon to strip up the membrane from the ends of the bony fragments he wishes to excise without injury to it. It is evident that the detachment of the periosteum must bear some relation to the condition both of the membrane and of the bone itself. The periosteum is more readily detached in growing subjects than in the adult, in chronic inflammation than in acute, and to a greater degree in some bones than in others.

The lower jaw, the clavicle, the bones of the forearm and arm would appear to present in the human subject unusual facilities for denudation, with relatively slight impairment of the vitality of the membrane, if the success attending operation on these bones serves in any way as a standard for comparison. The greater part of the shafts of these bones has been removed, and new bone has formed in its place through the agency of the periosteum. The other bones possess the property in a much less degree,—such as the bones of the lower extremity, and the flat and irregular bones generally. This property appears to be almost entirely absent in the bones of the brain-case.

Bone, while owing much of its genetic power to the periosteum, is not dependent thereon, but is indebted measurably, according to Dr. Alex. Ogston,[1] to the cartilage covering the articular surfaces. In the judgment of this observer articular cartilage is as valuable and necessary in forming and maintaining the structure and shape of bone as is the periosteum. He believes that there is a peculiar structure of the bone in this way produced which permits of its being readily distinguished from that of periosteal origin. "The former variety is marked out," he informs us, "by the main beams or trabeculæ of its mesh-work being placed at right angles to the bone surface, while periosteal bone is characterized either by its main trabeculæ being parallel to the bone surface or by there being no indication of any special direction observable in them at all."

Periosteum may be torn away from the bone to which it is attached by violent injury. In com-

[1] The trabeculæ differ in such slight degrees in different localities that it has been customary to include them in a simple description of each bone. This plan will be pursued in this work. At the same time the student is advised to study the sawed section of bone, for in no other way can the nice points of resistance and pressure as expressed in the details of bony structure be appreciated.

[1] Journ. of Anat. and Phys., 1878, 503. Numerous illustrations.

minuted fracture, portions of bone of variable size are thus denuded, and suffer from atrophy or death in consequence. Mr. Annandale[1] reports an instance in which the periosteum had been stripped from the patella in a case of rupture of the patellar ligament. In some forms of dislocation an analogous lesion occurs; such, for example, is the elevation of the strong layer of periosteum covering the posterior surface of the sternum in displacements of the manubrium upon the gladiolus,—the lower end of the former lying behind the upper end of the latter.[2]

Medulla.—The interior of the bone is occupied by a peculiar fatty substance which has received the name of the *medulla*. The membranous surfaces of the medulla, which lie in contact with the bone, have been often spoken of collectively as the *endosteum*, although such a membrane cannot be separated from the medulla. The spongy ends of the long bones, and the interior of the flat and irregular bones, do not possess the fatty medulla, but in its place there is a reddish flesh-like substance occupying the interstices of the cancelli, which, under the microscope, resolves itself into large nucleated cells. It is from this tissue that the fatty medulla has originated, since we find in the bones of the infant that the medullary cavity and the fatty medulla are absent, and that their places are occupied by the same tissue which is seen throughout late childhood and adult life in the extremities alone.

Fresh Bone.—The *fresh bone* is found to be of a faint yellowish-pink or bluish yellow color, the degree of bluish tinge being determined by the condition of the circulation at the time of the death of the individual. In deaths from drowning, or in analogous states in which the blood has become largely surcharged with carbonic acid, the bones are bluer than in deaths from other causes. The yellow color is due to the effect of the presence of the fluids in the body and the fatty medulla upon the white color of the osseous tissue. Bones of the young subject are more uniformly red than those of the adult.

Dry Bone.—When the blood, fat, membrane, and cartilage are removed from a bone, as, for example, by maceration, the color becomes white. In this condition the bone is porous. All the interstices and the canals leading thereto are freely continuous with one another; the bone thus absorbs fluid readily, and will permit a column of mercury to pass through it as through a sieve, from end to end.

The outer surface of the well-developed long bone, as the femur and humerus, is found to be marked by minute elevations, with intervening linear depressions, while here and there over the surface of the bone are small, flat, whelk-like nodules.

The surfaces are also pitted by innumerable minute orifices for bloodvessels, and near the extremities by larger ones (mostly for veins) opening from the bottom of the large depressions there present. The main nutritive canal of the long bone enters in some part of the shaft, and passes obliquely into the medullary cavity. The direction of this canal varies in the different bones. In the ulna, radius, and femur it is directed upward; and in the tibia and humerus it is directed downwards.

The dry bone, when exposed for a long time to the atmosphere, splits into laminæ. It is thus proved that the osseous tissue is laminated, and not homogeneous in structure.

Chemical Analysis.—Bone when subjected to chemical analysis yields:[1]—

Calcium carbonate	7.05
Magnesium phosphate	2.08
Calcium phosphate	58.39
Calcium fluoride	2.25
Organic matter	30.23
	100.00

Thus nearly one-third of the component parts of bone is composed of organic, and the remaining two-thirds of inorganic substances.

If bone be subjected to the prolonged action of an acid,[2] the inorganic substances are dissolved, leaving the organic unchanged. The form of the bone by this procedure is preserved, but its consistence is fibrous merely, and its strength and rigidity are lost. Such a specimen can be bent in any position by moderate force, and in the case of the fibula can be even tied in a knot.

If, on the other hand, the organic portions be removed, by subjecting a bone to the action of fire (as in a furnace), the organic matters are destroyed by burning, and the inorganic portions only are left. The form of the bone, as in the other procedure, is

[1] Edinburgh Med. Journal, 1875, 838.

[2] W. Rivington, Med. Chir. Trans., lvii. 102.

[1] Gorup-Besanez. Anleitung zur Qualitativen und Quantitativen Zoochemischen Analyse, 1871, 420.

[2] For this purpose a solution of hydrochloric acid in water may be prepared, having a strength of one part of acid to sixteen of water. The fluid should be renewed daily.

preserved, but the elasticity and the toughness are destroyed. The bone is thereby made preternaturally brittle, since it is composed entirely of bone-salts and ash.

The living bone with a deficiency of organic material is thus too brittle, as one with a deficiency of inorganic material is too yielding. The mean between these extremes results in the normal property of bone. This mean varies, however, according to age. The bone of the infant, with its want of medullary canal and small proportion of bone-salts, while admirably adapted to a state of development, would be the source of serious disadvantage in the adolescent or adult. In old age the bones become more brittle, owing to the loss they sustain in a diminution of their organic materials.

IDENTIFICATION OF BONES FOR MEDICO-LEGAL PURPOSES.

Courts of justice not infrequently demand expert testimony upon the nature of bony fragments submitted to examination, or upon the presumed peculiarities of the missing portions. Are the bones human? Do they belong to one individual? What was the sex, age, or height of the individual? Are the bones healthy or diseased? Do they show the effect of previous, recent, or old injury? Can the time since death be determined by examination of the fragments?

The propositions embraced in such questions necessarily involve many difficulties, most of which, however, can be readily overcome. In most cases special study of the suspected part can alone be relied upon in arriving at a decision, since the individual variations of bones prevent the following of fixed rules, no matter how carefully they may have been prepared.

The bones of the opposite sides of the body, while bearing a close resemblance to one another in general shape and in the relative development of the details of structure, will be often of different lengths. This fact, which tailors and shoemakers have observed from time immemorial, has awakened of late years professional interest.

Dr. Wm. Hunt[1] called attention to the fact that in the human body the lower limbs are of different lengths. According to the measurements of Dr. W. C. Cox,[1] this difference exhibits a range of from one-eighth to one-half of an inch. Dr. J. S. Wight,[2] in a subsequent series of observations, arrived at similar conclusions. Dr. Jeffries Wyman[3] had previously determined that the clavicles and ulnas differ in length.

In endeavoring to determine the sex of the individual, it must be borne in mind that the pelvis is the most characteristic portion of the skeleton, and that the difficulty of determining the point is rendered greater both before and after the child-bearing period. The well-known differences between the male and the female pelvis need not be repeated here. It will be observed that the bones of the female are smoother, smaller, and more delicate than the corresponding bones of the male. According to Sappey, the skull of the female is longer as compared to its breadth and height than is that of the male. The manubrium of the sternum in the female, according to Hyrtl, exceeds in length that of half the body of the bone; while in the sternum of the male the body is at least twice as long as the manubrium. Dr. Thomas Dwight[4] showed that this rule, like most of its kind, is open to many objections. Yet one-half of the specimens measured by this observer confirmed the statements of Hyrtl.

The bones of young subjects may be distinguished by the epiphyses remaining ununited with the shafts. The surface of the bone in contact with periosteum is less smooth than in the adult, and may present the appearance of the periosteum having been violently detached. The vascular openings are relatively large and numerous. The jaws are more or less occupied by developing teeth. Bones from an aged individual are either thinner or thicker than in the young adult. The outer wall of the orbito-temporal septum is thin and often diaphanous. The depressions in the bones of the cranial vertex for the Pacchionian bodies are deeper.

With regard to the readjusting of detached portions of a skeleton Meyer gives the following rule for placing the pelvis in its approximately correct position: Bring the anterior superior spines of the ilia and the spines of the pubes into the same vertical plane. This writer finds that a line running from the upper surface of the symphysis pubis to the transverse depression in the third sacral vertebra will form an

[1] Phila. Med. Times, Jan. 16, 1875; also Am. Journ. Med. Sci., Jan. 1879, 102.

[1] Am. Journ. Med. Sci., April, 1875, 438.

[2] Archives of Clinical Surgery, Feb. 1877, 283; Proc. Med. Soc. County of Kings, N. Y., Jan. 1878, 338.

[3] Proc. Boston Nat. Hist. Soc. xi., 1868, 246.

[4] The Identification of the Human Skeleton: a medico-legal study. Mass. Med. Soc. prize essay for 1878. Boston, 1878.

angle of 30° with the horizon nearly. According to Dwight (loc. cit.) the only objection to this rule is the exceptional fact that some subjects possess more than the normal number of vertebræ.

The point of the coccyx is usually a trifle above the lower border of the symphysis pubis.

In the female the centre of the body is at the symphysis pubis; though in women above the average height the centre is slightly above this point, and in those below the average slightly below it. In the male the centre is in average examples a little below the symphysis, but it is subject to some variations, as in the female.

In readjusting the dry or macerated bones of the limbs with the view of ascertaining the height of the individual, one-quarter of an inch must be allowed for the cartilages of the knee; one-eighth of an inch for the cartilages of encrustment of the astragalus and calcaneum; one-half of an inch for the remaining portions of the foot; and one-eighth of an inch for the joint between the occipital condyles and the atlas.

For further information on the above and allied topics the reader is referred to Dr. Dwight's valuable essay, previously quoted, from which the writer has freely copied and epitomized.

With reference to the question whether the bones are diseased, the same difficulties obtain as in studying the healthy bones. The lines of former fracture may be confounded with variation of the normal structure. The normal details of healthy nutrition may so resemble the products of inflammatory processes as not to be with certainty distinguished; while defects of development may be confounded with postnatal atrophic changes.

Nevertheless careful comparisons will greatly assist in determining these and other distinctions. In the specimen suspected of having sustained fracture the part should be carefully macerated, since some instances of alleged atrophic or diseased change (as for example in the neck of the femur) have been shown by this means to be old ununited fracture. Lines of exostosis or inflammatory outgrowth can be distinguished from the lines of union of fracture by making a section of the bone. If at any time the bone has been fractured the evidence of the old lesion will be seen in the interior as well as upon the surface; while, if it has never been so injured, the evidences of change are apt to be superficial, and even if deeply seated show increased thickness and density of the bone-tissue.

Exposed surfaces of healthy adult bone, more particularly those of the long bones, exhibit innumerable minute linear depressions which serve to maintain the periosteum in position. These are sometimes supplanted in bones of muscular individuals by sparsely distributed elliptical nodules (see p. 101). In chronic peripheral inflammation these linear depressions are exaggerated in depth, and the spaces between them are apt to form minute, irregular eminences. In extreme examples of the results of formative inflammatory change such eminences may be confounded with the hyperostosed condition following chronic periostitis. In bones showing the least sign of atrophic change the condition opposite to the above is seen to exist. The linear depressions disappear, and the bone is everywhere smooth. Occurring at inconstant and variable intervals are minute openings which can be distinguished from the orifices of vascular canals by their being neither oblique nor crater-shaped, but having sharp-cut edges on the level of the bone surfaces as though punched out with a cutting instrument.

A knowledge of the development of bone is essential to a correct understanding of some morbid processes. Thus the manner in which a bone will be affected by disease is oftentimes the same as that in which it was developed. The relations between the epiphysis and the shaft of a long bone will have to be remembered by the surgeon. The epiphysis may separate spontaneously in some diseases and injuries. In fracture of the neck of the femur, that portion of the neck attached to the epiphysis may become absorbed, thus restoring to the epiphysis its original contour. In chronic arthritis, a series of characteristic appearances are restricted to a line near to or lying within the epiphysis. A sequestrum may be commonly restricted to a shaft, or, rarely, to an epiphysis.[1] Disease of an epiphysis can affect the adjacent shaft as on the other hand disease of a shaft can affect the adjacent epiphysis. Many diseases of the joints have their origin in contiguous epiphyses.

The restriction of morbid processes to portions of bone which are distinct from the point of view of development, is well illustrated in the superior maxilla (*q. v.*).[2]

In the composition of the complex association of bones, such as those of the skull or sacrum, certain surfaces are found remaining free from contact with one another. These ordinarily afford transit to important nerves and vessels. In the instance of the

[1] Brodie, Surg. Lectures, 222, and Adams, Trans. Path. Soc. Lond., iii. 165, and Birnett, Ibid. vi. 288. Cat. to Mus. Guy's Hosp. No. 1484, 49.

[2] See also a paper by the author on Localization of Diseased Action in the Osseous System, Am. Journ. Med. Sci., July, 1870, 404.

thyroid or obturator foramen in the innominate bone, the opening is closed by membrane, which, however, is pierced for the passage of a small nerve and artery. The development of the more complex single cranial bones, such as the temporal and sphenoid, explains the apparent anomaly of nerves and bloodvessels piercing resistant bony walls. Each vessel and nerve will be found to lie between the several elements composing the bone, or in a foramen or canal near the margin of the several component parts. Thus the facial nerve, in its intricate passage through the temporal bone, passes *between* the parts making up the embryonic temporal bone. The branches of the fifth cranial nerve pass through the *margin* of bones near the primary interspace between distinct embryonic portions of the sphenoid bone. In young subjects the foramina isolating the different branches of a nerve are imperfect, and in some animals they have no separate existence. It is rare for a nerve to pierce a bone, as a small branch is sometimes seen perforating the clavicle, or a nerve and artery passing through a foramen above the epitrochlear process of the humerus.

REMARKS.

Bones as Mechanical Agents.—The student is especially urged to examine the bones as mechanical agents. He should constantly seek for the conditions which underlie or (not to speak too boldly) create the ossific forms. Thus, in studying the bones of the face, he should observe that the ascending nasal process of the superior maxilla is stout in order that it should receive and distribute the force of the occlusion of the lower maxilla against the upper; while the lachrymal bone immediately behind it is thin and weak, since none of the same or similar labor is exacted of it. Likewise, in the innominate bone the prismatic elevation extending from the sacro-iliac symphysis to the acetabulum comprises the most massive portion of the bone, since it is the supporter of the sacrum and indirectly of the superimposed vertebræ; while the bone on either side of the thickening (often so thin as to be translucent) possesses little or no strength.

Variations in the Shapes of Bones.—Variations in the form of bones are due to alteration of (1) blood-supply, and (2) the strength of muscular attachments.

(1) In studying the varieties of form due to blood supply, it must be remembered that the needs of the tissues determine the quantity of blood going to them. Hence, variations with a tendency to excess of size are found in locations showing the greatest functional activity, while variations of reduction of size are seen in locations of diminished activity. For instance, the variations in the form of the atlas are of two kinds—those in which the lateral portions of the bone are larger than usual, and those in which the median portion of the bone is smaller than usual. The former is explained by the fact that increased functional activity has led to increased vascular supply; and the latter by the fact that the retarded activity has led to diminished vascular supply.

The direction by which arteries enter the long bones will be seen to determine the degree of vascularity at the ends thereof. Thus the nutrient vessel of the shaft of the femur being directed upward, congestion of the medulla is more apt to occur at the proximal than at the distal part of the bone. The nutrient vessel of the tibia, running as it does downward, will tend to fix the position of congestive change at the distal end of the bone. After fracture of a long bone, the portion remote from the main source of blood-supply may undergo atrophy.—Epiphyses are very vascular, as compared to the shafts of bones, and, all things being equal, the longer the period of separation of an epiphysis from its shaft during development the longer is the vascularity of the epiphysis sustained, and therefore the greater the liability it incurs to the invasion of disease.

(2) The lines of tendinous insertion of muscles of the limbs often modify the surfaces upon which they appear, and serve as boundaries of topographical divisions of the bones. This is conspicuous in the humerus, ulna, femur, tibia, and fibula. In the last two bones, the lines fixing the interosseous membrane—itself an intermuscular septum—separate the anterior from the posterior surfaces. The linea aspera of the femur is exclusively a ridge of muscular significance, and is determined by the fibres of the tendons of the adductor and extensor muscles here aggregated.—The lines of exaggerations of growth seen in bones are apt to be associated with the relations of the fleshy parts. They oftentimes constitute the minor degrees of difference between bones of individuals, and even between the corresponding bones on the opposite sides of the same individual. They give, in addition, the best clue to causes for location of morbid growths, particularly the exostoses. The exostoses often existing in the line of the condylar insertion of the Adductor Magnus muscle (the "rider's bone"), as well as the osteophyses along the lines of intermuscular septa at the lower part of the fibula, are of this significance.

In muscular subjects the humerus is often obscurely angulated at the part at which the Deltoid muscle is attached. This is sometimes so pronounced as to form a variety in the shape of the bone. In other bones the surface of origin for the third head of the Triceps muscle is convex instead of flat, and gives the bone the appearance of being bowed forwards. If such a specimen be laid upon a plane surface, the distal end of the bone will not touch the plane—the bone resting upon the head and the centre of the above-named tricipital surface.—Specimens of chronic ostitis of the humerus are not rare in which the disease has been confined to this portion of the humerus.—On the other hand, an osseous surface is sometimes seen covered

by a broad smooth muscle, and is in this way protected from the tendency to excessive growth elsewhere evident. The impression of the Temporal muscle is rarely the seat of diseased action of any kind. In some remarkable examples on record of diffused cranio-facial exostosis the temporal regions are entirely free from disease.[1]

Many processes of bone are created, as it were, by muscular traction. Thus the pterygoid process of the sphenoid bone has no existence in animals, whose muscles for moving the lower jaw are disposed in a manner different from those of man and mammals. The massive mastoid process is absent when the Sterno-Cleido-Mastoid muscle is also absent, as in most quadrupeds. The femur of some animals, such as the rhinoceros, possesses three trochanters. Two of these correspond with those found in man. The third is for the insertion of muscular slips not found in man, except as anomalies. It can be said, indeed, that the trochanters in the human femur are correlative with the muscles inserted into them. In the absence of the muscles the processes would never have appeared.

The effect of muscular action in modifying the shapes of bones has formed the subject of special study by Prof. Henry J. Bigelow.[2] According to this writer, the inter-trochanteric ridge of the femur is simply a buttress erected for the insertion of muscles upon and over the true neck, which is represented by a more deeply-seated septum or layer of compact tissue (see Femur). Dr. Thomas Dwight[3] detects similar superficial deposits of bone beneath the anterior inter-trochanteric ridge, and sometimes under the coronoid process of the ulna and the tubercle of the radius.

Muscular Action as a Cause of Ostitis and Necrosis.—Diseased processes may be excited through muscular action. Necrosis has been known to follow ostitis, the result of prolonged traction of a muscle upon the bone yielding its points of insertion. Prof. Syme,[4] in commenting upon a case of sinus of the hip depending upon exfoliation from the pelvis, states that the patient had first experienced uneasiness after a day's employment in curing herrings, and that the discharge of his duty had required him to stand with his feet apart, alternately stooping and stretching his arms upwards to the full extent; subsequently to which he had felt a painful sense of fatigue in the back part of the thighs. It then occurred to the author that the disease had originated from over-exertion of the muscles which arise from the tuberosity of the ischium, and that the bone with which they are there connected had suffered in consequence so as to exfoliate instead of being excited to preternatural growth, as Sir Astley Cooper with apparent good reason thought likely to happen from inordinate muscular contraction. It seemed evident enough that injuries similar to the foregoing cannot result from the direct effect of violence, since in all the cases detailed the bone concerned was securely protected by its situation from any such injury. In all of them there was violent muscular contraction, and it seems probable that this may have been the exciting cause of inflammation and death of the bone.

The Shapes of Bones as Modified by Diseased Action.—Bones serve as resistant masses to the superincumbent weight of the body. In rickets and other diseases which tend to soften the bones, characteristic deformities are found to result from the bones yielding to the weight of the tissues.

The base of the skull may become flattened from the weight of the brain, and the bones of the vertex distended and distorted from pressure from within. The bones of the lower extremities from analogous causes become bent. In the long bones which have undergone softening, but which have regained their former toughness and rigidity, strong ridges are observed upon the concave aspects of the curve; and this superabundant bone, according to Stanley,[1] is placed exactly where the curvature of the bones renders them mechanically weaker, and where, consequently, their greatest waste of tissue occurs. This compensative arrangement is called by Stanley reparative hypertrophy.

Bone may also be altered in form by pressure which has been long maintained against it. An aneurism in an artery lying upon a bony surface will cause the absorption of the bone at the place of greatest pressure. Thus aneurism of the ascending aorta will create absorption of the sternum or ribs; and aneurism of the descending aorta, of the bodies of the vertebræ. Tumors of other kinds will in the same way cause bone to yield; tumors of the tongue will create deformation of the jaws, and tumors in the nose and pharynx will press upon and destroy the bones of the nasal region. One of the most remarkable instances of this pressure seen in the latter locality is reported by Hilton,[2] in which an osseous tumor of the left side of the face had distended the superior maxilla and adjacent structures to a remarkable extent. The mass subsequently underwent spontaneous evulsion, but the deformity created by its former presence persisted, in addition to which a cavity communicating with the enlarged nostril remained.—An hydatid tumor placed between the left lung and the diaphragm has been known to cause absorption of the bodies of the vertebræ and to permit intrusion of the hydatids into the vertebral canal. This intrusion occurring suddenly gave rise to the impression that hemorrhage had occurred in the spinal cord.—Even the petrous portions of the temporal bone will not long resist contact with a tumor much less compact than itself. Dr. Morris Longstreth,[3] in dissecting the relations of a sarcoma

[1] H. Lebert. Traité d'Anat. Pathol. 1857. Atlas, pl. xxxii. Murchison, Trans. Path. Soc. London, xvii. 243, pl. 10.

[2] The Hip, 1869, 125.

[3] Journ. Anat. and Phys., 1875, 311.

[4] Ed. Med. and Surg. Journ., 1828, contains Syme's original notice of this subject.

[1] Illustrations of the Effects of Disease and Injury of the Bones. London, 1849, pl. xx. p. 22.

[2] Guy's Hosp. Rep., i., 1836, 493.

[3] Burnett's Treatise on the Ear, 555.

which had originated in the left cerebellar hemisphere, and had sent a portion of its mass within the internal auditory meatus, noticed that the bony canal was much widened and funnel-shaped. In a case reported by Bœttcher[1] the tumor had dilated the canal in all directions.

Interstitial absorption from undue pressure plays an important part in the causation of deformity of the spine, in which condition bodies of the vertebræ become changed in outline—sometimes to a remarkable extent—not from any primary diseased action therein, but from long-continued vicious pressure. The question of prognosis in all cases of spinal deformity must be wisely based upon what is known of the deformed shapes of the vertebræ entirely apart from the question of removal of the original exciting cause.

Bones, in addition to the modifications of their surfaces due to the origin and insertion of muscles, may be changed in form at certain localities by tendons and bloodvessels. The tendon of the Obturator Internus, as it lies over the innominate bone above the tuberosity of the ischium (creating grooves even in the normal bone), will cause deeper and broader grooves to appear in bones which are preternaturally softened. In a skeleton of a giant, preserved in the Mütter Museum in Philadelphia, the exaggeration in these grooves is well represented.

In like manner the points of origin and insertion of muscles will cause in young bones, or in those of the character above described, the opposite effect, and will create shallow depressions upon the surface of the bone instead of prominences.

THE VERTEBRÆ.

General Considerations.

Every vertebra, excepting the atlas, is composed essentially of three parts, viz., a body, and two lateral portions.[2] The body defines the vertebral canal in front, and the lateral portions at the sides and behind. Each lateral portion arises from the posterior outer margin of the body, and passes for a short distance outward and backward. It is thence abruptly deflected inward and backward, and joins its fellow of the opposite side to form at the point of contact *the spinous process* or *spine*. The union of the lateral portions constitutes *the vertebral arch*. The figure of the vertebral foramen thus determined by the convergence of the lateral portions is triangular, and presents one posterior and two lateral subrounded angles.—The vertebral canal accommodates the spinal cord and membranes; the spinal nerves, as they pass from their apparent origin in the spinal cord to their points of exit from the vertebral canal; the vertebral artery on its way from the vertebral foramen of the atlas to enter the foramen magnum; and the lymph-space between the membranes.[1]

The cancelli.—The lines of cancelli in the vertebræ are arranged in three series. The first consists of longitudinal concave lines with their concavities directed forward. The second resembles the foregoing, but the concavities are directed backward. The third series are transverse,—the upper lines being concentric to the superior, and the lower to the inferior articular surface.

The other general features of a vertebra are the following:—

The *pedicle*, which is that rounded part of the lateral portion lying between the body and the lateral angle; the *lamina*, the thin, flattened part lying between the lateral angle and the spine,—it is seen to be vertically compressed at its base; the *superior oblique or articular process* lying at the base of the pedicle,—it presents an articular facet looking backward; the *inferior oblique or articular process* lying upon the base of the lamina at the angle,—it presents an articular facet looking forward; *the inferior notch* lying beneath the pedicle, and between the body of the vertebra and the lamina; and the smaller *superior notch*—a less constant feature—lying upon the pedicle between the body and the superior articular process.—In articulation the apposition of a pair of superior and inferior notches constitutes an *intervertebral foramen* for the exit of a spinal nerve.

THE VERTEBRAL COLUMN.

The vertebral column is the figure resultant upon the apposition of the vertebræ in natural order. It is usually accepted to include the sacrum and coccyx. But for practical purposes nothing is gained by thus

[1] Archiv Oph. and Otol., iii. 134.

[2] The atlas, while defining the vertebral canal in common with the other vertebræ, is composed of two lateral portions only, and is technically without a body.

[1] The vertebral canal varies greatly at different parts of the column. According to Humphry, the antero-posterior diameter, within the axis, is but $\frac{5}{8}$ of an inch; from this it gradually diminishes to $\frac{3}{8}$ of an inch at the middle of the dorsal region. Opposite the last lumbar vertebra it increases to $\frac{7}{8}$ of an inch, and thence rapidly diminishes until the sacrum is reached. The frontal diameter at the atlas measures $1\frac{1}{2}$ inch, at the axis 1 inch, at the second dorsal vertebra $\frac{6}{8}$ of an inch, at the last $\frac{7}{8}$ of an inch, and at the lumbar vertebræ 1 inch.

uniting these parts, since special descriptions and entirely distinctive relations are required properly to elucidate them. Omitting, therefore, the sacrum and coccyx, the vertebral column is composed of—

7 cervical vertebræ,
12 dorsal vertebræ,
5 lumbar vertebræ,

making a total of 24 bones.

The vertebral column is best studied when the intervertebral disks, ligaments, and articulations are in position. By this union of the separate bones, the intervertebral notches become connected into intervertebral foramina; the various segments of the vertebral canal join with one another; the facets for articulation of the ribs become complete sockets; and the space in each bone between the spinous and the transverse processes extending the entire length of the spine,[1] becomes known as the vertebral groove.

As a whole, the vertebral column protects the contents of the vertebral canal, affords attachments to important muscles, and supports the head, while guarding it from shock. It serves in front to protect the viscera, and in an indirect manner to furnish points of attachment to structures holding the viscera in position. Thus the descending aorta is firmly fixed to the spine along its entire course,—and from and about it the mesenteric and other peritoneal folds arise.

The vertebral column increases in size from above downward, and may be said to rest upon the sacrum by the massive bodies of the lumbar vertebræ. Its form, therefore, is pyramidal, but this form is much modified by the presence or absence of ribs as well as by surfaces for ligamentous and muscular attachments. Its *length* is about one-third that of the body.

Mechanics of the Vertebral Column.—The mechanics of the vertebral column embraces three distinct subjects:—

(1) The adaptation of the vertebræ to support the head.
(2) The degree of motion present between the vertebræ.
(3) The production of spinal curvatures.

(1) *The adaptation of the vertebræ to support the head.*—The head rests directly upon the lateral portions of the atlas. The weight is thence conveyed through the superior articular processes to the bodies of the vertebral column, but a portion is sent to the lateral masses of the remaining cervical vertebræ as well, and through them to the bodies of the dorsal and lumbar vertebræ. There are thus two lines of weight in the vertebral column: one direct through the superior articular facets of the axis to the bodies; and another passing from the same point downward through the columniform articular region of the cervical vertebræ to the dorsal region, whence it again passes to the bodies, which now sustain the weight of the superincumbent mass.

The shape of the spine directly assists in sustaining the weight of the head. According to F. O. Ward,[1] the lumbar region—the most massive—contributes seven parts to the column; the dorsal, eleven; and the cervical, five. The lumbar and nine lower dorsal vertebræ form a pyramid whose base rests on the sacrum. The six lower cervical vertebræ form another pyramid, whose base rests on the first dorsal, and whose apex is surmounted by the atlas on which again is balanced the globe of the cranium. Between these two pyramids, and extending from the base of the upper to the apex of the lower, intervene the three superior dorsal vertebræ, which constitute a third, but inverted pyramid. Thus, though the whole column presents a cone whose base is somewhat more than double the diameter of the apex, yet this main pyramid is composed of three subordinate pyramids. It is evident from this disposition of parts that a structure of enormous strength arises well adapted to the special demands made upon it.

(2) *The degree of motion present between the vertebræ.*—The articular processes are also of great importance in the mechanics of the vertebral column. The motion between the articular surfaces is greater in the cervical than in either the dorsal or the lumbar region. On the whole it may be said to become less in regular degree from above downward. In the lumbar region the inferior articular processes are in a measure embraced by the superior. In the dorsal region the surfaces are simply apposed, but the motion between them is impaired by the imbrication of the dorsal spines and the manner of articulation of the ribs.

(3) *The production of spinal curvatures.*—The weight of the body above, and the traction of muscles at the sides, cause the vertebral column to assume a number of curvatures. These modify the shapes of the bones, and enable them to best accommodate themselves to the forces mentioned. The peculiarities of shape of the bodies, the intervertebral

[1] It will be noticed that the words "spine" and "vertebral column" are used synonymously, as are the words "spine" and "spinous process."

[1] Outlines of Human Osteology, 18.

disks, the articular processes, etc., are all moulded to one another, as a series of effects, by the kinds of pressure and traction to which they have been and are subjected. To such an extent, indeed, is this the case that the curvatures remain after the spine has been detached from its surroundings.

The antero-posterior curvatures.—The main curvatures are antero-posterior, and are three in number —the *cervical*, the *dorsal*, and the *lumbar*. The first presents a convexity forward; the second, backward; and the third, forward. The figure of the spine is thus sinuous.

Humphry[1] has accurately defined the curves of the spine to be as follows: The first or cervical curve begins at the top of the odontoid process, and terminates at the middle of the second dorsal vertebra. It has its convexity in front, and forms 18° of a circle whose radius measures 6⅝ inches; the most prominent point anteriorly is the forepart of the body of the fourth cervical vertebra.—The second or thoracic curve begins at the middle of the second, and terminates at the middle of the last dorsal vertebra. It has its concavity forwards, and forms 42° of a circle, whose radius measures 12⅜ inches; the most prominent point posteriorly is the hinder edge of the body of the seventh or eighth vertebra.—The third or lumbar curve, beginning at the middle of the last dorsal, terminates at the lower and anterior edge of the last lumbar vertebra. It is convex anteriorly, and forms 80° of a circle, whose radius is 5⅜ inches.—The fourth or pelvic curve, sharper than either of the others, begins at the upper edge of the sacrum, and terminates at the top of the coccyx. It forms 125° of a circle, whose radius is 2⅝ inches. The degree of curvature is not uniform, but is greatest a little below the middle.

The relation of weight to curvatures. — A direct line from the superincumbent weight at the head passes through the odontoid process and points of confluence of spinal curves, and falls a little in front of the promontory of the sacrum. This line passes through the points at which the vertebral curves run into and support each other. Lying in advance of the bodies of the fifth to the ninth dorsal vertebræ inclusive, it leaves a larger portion of the dorsal curve behind the line of gravitation than is the case in the cervical and lumbar regions. In the stooping position the line falls further in front of the one above indicated.

The curves are most pronounced in persons who have the greatest degree of normal exercise of the body, as in savages, and in those whose occupations accustom them to carry weights on the head. On the other hand, they are defective in persons of a sedentary habit and in bed-ridden invalids.

The curves are liable to change when the position of the weight is shifted. In forced stooping the lumbar curve is obliterated and actually slightly reversed. In the sitting position the hollow of the spine at the lumbar region disappears.

Lateral curvatures.—The existence of normal lateral curvatures in the spine has been a subject of some difference of opinion among anatomists. Dods, in 1824, appears to have been the first clinical writer accurately to define the condition. Quain, Humphry, and Ward among systematic writers describe a slight degree of lateral curvature as observable in most cases in the dorsal region. Its convexity is directed to the right—a result due presumably to the greater use made of the right than of the left arm. According to Beclard, a curvature is exhibited to the opposite side in left-handed persons. This statement is disputed by Adams,[1] who doubts the existence of lateral curvature as a physiological condition.

That such a curvature, however it may be classified, is dependent upon muscular action has been generally maintained by observers, who are inclined to accept the kind of explanation presented by Quain as applicable to all examples. Lateral curvature is never seen, according to Sayre,[2] in vigorous subjects who are habituated to carrying weights on the head; since both right and left groups of the muscles of the spine are here equally exerted. If a lateral curvature is developed in the dorsal region, which is commonly the case, a secondary compensatory curve in the opposite direction is developed in the loin.

Lateral curvature may also follow upon the insufficient support given the entire trunk by inequality in the lengths of the lower limbs. In cases where one limb is much shorter than the other, as in fracture of one of the bones of the lower extremity followed by much shortening (or in paralysis or insufficient development), the side of the pelvis answering to the shortened limb falls, and a compensatory lateral deviation of the spine from the normal line always ensues.

Lateral curvature with rotation. — Humphry[3] noticed, as early as 1850, that in lateral curvature the motion is not simply of a lateral character, nor

[1] The Human Skeleton, 147.

[1] See p. 109.

[2] Spinal Disease and Curvature, 92.

[3] L. c., 171.

one strictly confined to the sides of the bodies, but that the hinder parts of the sides, or the points of confluence of the arches and bodies, are involved, viz., at the points at which the vertebræ remain cartilaginous after the rest of the bodies and arches have become ossified. It is certainly suggestive that these curvatures are common in young growing persons. In consequence of the above-named parts yielding, the bodies become twisted or *rotated* a little to the opposite side. This writer calls the motion thus described the vertebral twist, and states that it is an almost constant accompaniment of lateral curvature. A. B. Judson[1] has also arrived at the conclusion that a rotatory motion of the bodies of the vertebræ is present in lateral curvature, and, indeed, initiates the movement. His theorem, which is stated independently of Humphry's, and varies therefrom, is based upon the fact that the posterior portion of the vertebral column, being a part of the relatively fixed dorsal parietes of the chest and abdomen, is confined to the median line of the trunk; while the anterior portion, projecting as it does into the thoracic and abdominal chambers, and being devoid of lateral attachments, is at liberty to move to the right and left of the median line. By means of an appropriate apparatus, this observer induces lateral curvature with rotation of the vertebræ by vertical pressure received upon the summit of a vertebral column whose base is fixed. Double curvature with rotation in each curve may be produced by confining one of the dorsal vertebræ at the same time that pressure is exerted from above. These experiments appear to have been made on an artificial preparation of the spine, without ligaments. They need repetition on a trunk with ligaments, muscles, ribs, diaphragm, and liver in place before the results can be accepted.—The rotatory motion is freer at the upper part of the dorsal region than elsewhere, being slight in the neck, and absent in the loin and its transition to the dorsal region.

According to W. Adams,[2] "The articular processes undergo very important structural changes at an early period of the formation of lateral curvature. The articular facets become altered in their direction and aspects, according to the extent of the lateral deviations of the bodies of the vertebræ—thus increasing in degree of alteration in proportion to the severity of the case. In the lumbar region where these articular processes are naturally nearly vertical in direction—looking inwards and outwards respectively—they gradually assume in a severe case of lateral curvature a very oblique direction. In lateral curvature with rotation, the transverse processes are depressed towards the abdominal cavity, and, in severe cases, cannot be felt by external examination; whilst those on the convexity of the curve project backwards towards the skin, and may even rise to the level of the apices of the spinous processes, and be readily felt along the outer margin of spinal muscles, which they also protrude backward and are rendered prominent. This deviation in the direction of the transverse processes is extremely important in a diagnostic point of view, and will enable the observer to diagnose a curvature in the lumbar region in cases in which no lateral deviation of the spinous processes exists."

THE INTERVERTEBRAL FORAMINA.—The intervertebral foramina vary in different regions. They are more forward in the neck, where they are small and round, than in the loins.

THE SPINES.—The spines are arranged in accordance with their degrees of motility. They are directed either horizontally backward or slightly downward in the neck and loins—but downward and backward in the dorsal region, where they overlap. In the neck they are distinct and wide apart, and permit the ligamenta sub-flava to be seen from without. In the region of the back they overlap. In the loin, while not overlapping they nearly touch one another, and protect the vertebral canal and contents.

HOMOLOGIES.—Study of the development of the vertebræ has proved that the *transverse processes* of different vertebræ are not of the same homological value.

The anterior tubercle of the transverse process of a cervical vertebra represents, it is thought, a rudiment of a rib, since it answers in position to the rib of a dorsal vertebra, and arises from a distinct centre of ossification. In like manner the transverse process of a lumbar vertebra may be held to be homologous to a rib. The transverse process of a dorsal vertebra is homologous to the posterior tubercle of a cervical vertebra, as well as to the accessory process of a lumbar. Reference to this arrangement furnishes the true explanation of the anomaly of the anterior tubercle of one of the lower cervical vertebræ being found as a true rib-like quantity.

[1] Trans. N. Y. Acad. of Med., 1876, 315. Literature.

[2] W. Adams, Med. Times and Gazette, Dec. 7, 1861, 574.

Transition vertebræ.—While the characters of the cervical, dorsal, and lumbar are quite distinctive, the upper dorsal resemble the cervical, and the lower the lumbar. Thus the first and second dorsal vertebræ have bodies recalling those of the cervical; in the tenth to the twelfth dorsal vertebræ, the rudiments of the accessory and mammary processes are present; and the floating rib suggests a lumbar transverse process which is merely unfixed.

DEVELOPMENT.

Each vertebra arises from three main centres of ossification,—one for the body of the bone, and one for each of the two lateral portions, including the laminæ. The centres for the latter appear about the seventh week, and the centre for the body about the eighth week. These parts are separate at birth.

In addition to the above an epiphyseal centre arises within the spinous process and the transverse processes of the vertebræ about the sixteenth year. In the lumbar vertebræ both of the mammillary processes receive a similar centre. The body is furnished with two accessory centres—one on either side—at about the twenty-first year.

The development of the atlas and axis differs from the foregoing.—The *atlas* is without a distinct centre for the body. The two centres of ossification within the laminæ extend across the cartilaginous anterior arches, one or two inconstant centres appearing therein at about the first year.—The *axis* arises from a centre for each lateral mass; one for the body, which appears at the sixth month; and two for the odontoid process, which appear at about the same time. These are united to the body near the third year. An additional accessory centre is seen occupying the odontoid process.

The development of the anterior tubercle of the cervical transverse processes may differ from that of the other vertebræ by reason of the morphological relation existing between this tubercle and one of the series of ribs. The tendency of the tubercle to have a distinct development from the remainder of the transverse process increases as the dorsal vertebræ are approached. The seventh cervical usually possesses a distinct centre in this process. Failure of union between this centre and the rest of the bone gives origin to the so-called cervical rib (see p. 000).

The transverse processes of the lumbar vertebræ may remain distinct from the body of the bone in the manner just indicated.

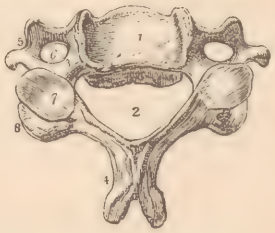
Embryology demonstrates that the vertebral column arises from two distinct portions of the dorsal layer of the embryo. The bodies of the vertebræ arise from beneath the medullary groove in and about the elements of the chorda dorsalis, called the protovertebræ. The elements of the future laminæ lie within the medullary folds at the side of the groove. It is plain that the method of growth of the body is different from that of the laminæ, and that the errors of development witnessed in the latter will be the result of the imperfect approximation between the right and the left sets. The laminæ most frequently failing to unite with one another are at that portion of the column which attains perfection last, namely, the lower portion of the lumbar series. This defect of union is known under the name of spina bifida.

THE CERVICAL VERTEBRÆ.

The cervical vertebræ are the vertebræ of the neck. The *body* of each cervical vertebra (fig. 1, Plate XIII.), excepting that of the atlas and axis, is broader from side to side than from before backwards, and is slightly inclined downward and forward. The upper surface is concave from side to side, and possesses an elevated lateral border. The lower surface is slightly concave from before backward, and yields a pronounced anterior border (fig. 1, Plate XV.). Its lateral edges appear to a trifling extent upon the sides of the body as shallow depressions.

Each *lamina* (Fig. 67) springs from the body at about its middle. The *pedicle* is rounded, and is directed outward until it reaches the mass between the articular processes. Beyond the articular processes the lamina becomes thin and compressed, inclines backward, joining the lamina of the opposite side to form the bifid *spine*, and to give shape to the somewhat triangular vertebral canal. Lying above the

Fig. 67.



1. The body. 2. The vertebral canal, formed at the sides by the laminæ. 3. The pedicle. 4. The laminæ, converging to form the bifid spine. 5. The transverse process. 6. The vertebral foramen. 7. The superior articular process. 8. The inferior articular process. The superior notch is indicated as the space between the body and the superior articular process.

pedicle, and between the lateral border of the body and the superior articular process, is the *superior notch*. Lying below the pedicle, and between the outer side of the body and the inferior articular process, is the *inferior notch*.

The *articular processes* are inclined parallel to one another downward and backward. The *superior articular process* looks upward and backward; the *inferior* looks downward and forward. The portion of bone intervening between the articular processes is massive and columniform.

The *transverse process* arises by two roots—a posterior or larger arising from the pedicle, and an anterior or smaller arising from the body. The process looks directly downward, and is pierced at its base by the *vertebral foramen* for the transmission of the vertebral artery. The process is grooved above for the anterior branches of the cervical plexus (fig. 1, Plate XV.), and presents an anterior and posterior tubercle; the Scalenus Anticus muscle is attached to the former, and the Levator Anguli Scapulæ muscle to the latter. The anterior tubercle, from its serving as a guide for tying the carotid artery, is called by Lisfranc *the carotid tubercle*.

The first (atlas), the second (axis), and the seventh cervical vertebræ (vertebra prominens), having many peculiar features, demand separate descriptions.

THE ATLAS.

The atlas or first cervical vertebra (fig. 2, Plate XIII.) is without body or spinous process. It is further characterized by the greater size of the lateral masses, by the conspicuous transverse processes, by the intervertebral grooves being placed behind the superior articular surface, as well as by many negative features. In place of the body, a short arch is seen which is known as the *anterior surface* or *arch*. This extends between the lateral masses in front, while joining them behind is the larger *posterior surface* or *arch*.

The *anterior arch* arises from the entire anterior borders of the lateral masses. It is compressed from behind forward, and is furnished in front by a prominence known as the *anterior tubercle* for the attachment of the Longus Colli muscle. Behind it is seen a large facet for articulation with the odontoid process of the axis.

The *posterior arch* arises from the middle of the posterior border of the lateral mass, where it is compressed from above downward, and grooved (*sinus atlantis* or *intervertebral groove*) for the vertebral artery. The hinder portion is more robust, and yields a minute *tubercle* for origin of the Rectus Capitis Posticus Minor muscle.

The *transverse process* is directed slightly downward and outward, and presents a broad, scarcely bifid extremity. Its anterior root arises from the upper border of the lateral mass; that portion behind the foramen arises from the middle of the lateral mass, and merges thence with the origin of the posterior arch. The under surface of the process is roughened. The transverse process, as in the other vertebræ, excepting the seventh, transmits the vertebral artery. Each lateral mass presents above and below an articular surface, and the two elements defining the vertebral foramen are more completely fused beyond the foramen than in the other vertebræ.

The *superior articular process* is of an oblong shape, and is concave for articulation with the occipital condyle. Its anterior and lateral edges are thin, and nearly on a level with the anterior arch. The posterior border is thickened, and forms a projection above the groove for the vertebral artery and first cervical or suboccipital nerve.

The *lower articular* process is more rounded than the upper. It is scarcely at all concave, and is directed obliquely upward and inward, and often slightly projects at the sides and in front.

The inner border of the lateral mass is roughened, and lies within the vertebral canal. It presents a tubercle, lying directly above the inner border of the inferior articular surface, for attachment of the transverse ligament.

The vertebral canal is relatively larger than in other vertebræ, and is remarkable for its contraction between the lateral masses for the accommodation of the odontoid process and the crucial and the check ligaments (fig. 2, Plate XXXVI.). The posterior half of the canal defined between the laminæ is wider than deep, and receives the spinal cord and vertebral arteries and veins (fig. 3, Plate XXXVI.).

Remarks.—The *sinus atlantis* may be converted by an osseous bar into a foramen.—A spicule of bone may spring from the posterior arch at the upper surface of the point of junction of the lamina and the pedicle, and pass over the position of the vertebral artery and the suboccipital nerve to the back part of the superior articular surface. A second spicule may pass from the upper surface of the transverse process to the outer edge of the superior articular surface,

crossing the place of exit of the anterior division of the first spinal nerve.[1]

The atlas tends in its varieties to hypertrophy of its lateral and atrophy or defective development of its median parts. The former variety may have the anterior tubercle of exaggerated size, when the prominence felt in the neck behind the angle of the lower jaw would be larger than usual; a process of bone may arise from the upper surface, and may even join the rarely present para-mastoid of the occipital bone. Of the latter variety, the anterior arch may be imperfectly ossified and a joint intervene, and the posterior arch be entirely absent, or a median hiatus of considerable size may exist which is occupied by fibrous tissue.

In a very instructive case reported by Küssmaul and Tenner,[2] an exact relation was detected between defective development of the atlas and the recurrence of epileptic convulsions. The patient was a boy twelve years of age, and the attacks supervened only upon rotation of the head. The coincidence of this motion with the attacks led to a careful examination of the parts after death. The defect of development described in the preceding paragraph was found to exist. The right segment of the imperfect arch passed across the median line nearly to the opposite side of the bone, and overlapped the left segment by one-third of an inch. The head being strongly rotated upon the spine, the ends of the imperfect posterior arch were seen to move forward, and in so doing the capacity of the vertebral canal was diminished and its contents compressed. It was inferred by the reporters that such action of the parts had followed each act of rotation during life, and, as a result of the spinal compression in this way induced, the convulsions had ensued. This conclusion appears to be a reasonable one, since it is in full harmony with the causation of at least one form of epilepsy as defined by writers on nervous disease, namely, that caused by pressure against the brain and spinal cord from exostoses, etc.

It is seen from this case that a deformation, which is at first sight of purely theoretical significance may be of great importance as an exciting cause to diseased action.

[1] W. Allen, Journ. Anat. and Phys., xiv., 1879, 18.

[2] Moleschott's Untersuchungen zur Naturlehre der Menschen und der Thiere, 1857, iii. 122.

THE AXIS.

The axis or second cervical vertebra (figs. 3 and 4, Plate XIII.) presents a body which is compressed from before backwards and furnished above with a conspicuous tooth-like process,—the odontoid process. The *laminæ* of the axis are massive, but its transverse processes are small and possess but a single tubercle. As is the case with the atlas there is no superior notch, *i. e.*, the superior facet is placed in front of the intervertebral groove.

The *body* of the axis is marked in front by a vertical eminence, upon either side of which is a depression for attachment of the Longus Colli muscle.

The *anterior border* of the under surface is produced below the level of the posterior.

The *lower surface* is moderately concave for reception of the third cervical vertebra.

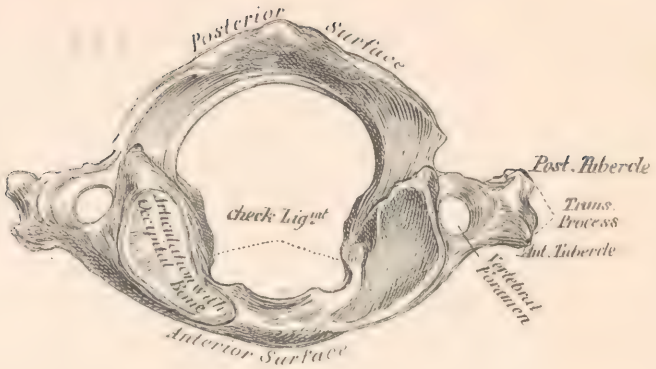
The *upper surface* is furnished with the conspicuous *odontoid process*. This is a vertical cylindrical eminence, whose anterior surface is slightly inclined backward, but whose posterior surface is nearly vertical. Its lip is sometimes prolonged. The lateral surfaces of the process near the lip are depressed for attachment of the powerful check ligaments. The process is constricted at the base behind, and at the sides by a well-defined neck for the accommodation of the transverse ligament. The anterior surface presents an oval facet for articulation with the atlas (fig. 3, Plate XXXVI.).

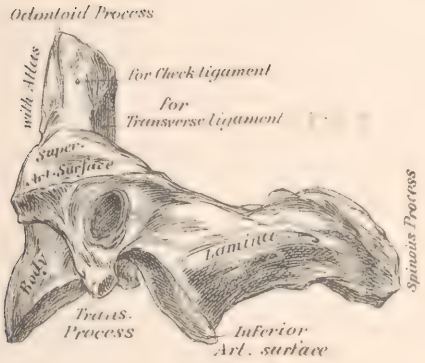
The *laminæ* of the axis arise from nearly the entire side of the body; directly behind the superior articular process the upper border is faintly depressed to form the *inter-vertebral groove* for the passage of the second cervical nerve. The *spinous process* is mas-

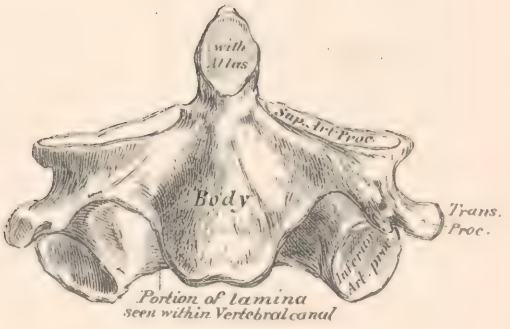
EXPLANATION OF PLATE XIII.

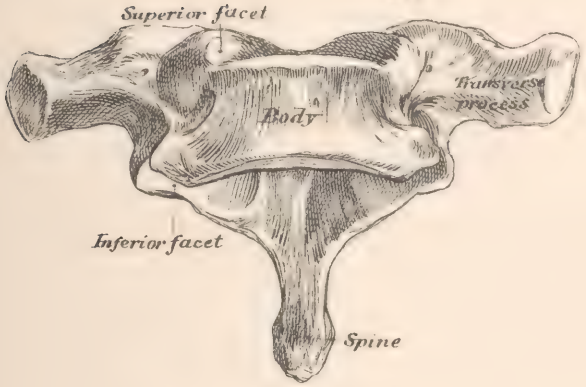
Fig. 1. A cervical vertebra, seen from in front.
Fig. 2. The atlas, seen from above.
Fig. 3. The axis, seen from the side.
Fig. 4. The axis, seen from in front.
Fig. 5. A dorsal vertebra, seen from in front.
Fig. 6. A dorsal vertebra, seen from the side.
Fig. 7. A lumbar vertebra, seen from in front.
Fig. 8. A lumbar vertebra, seen from the side.



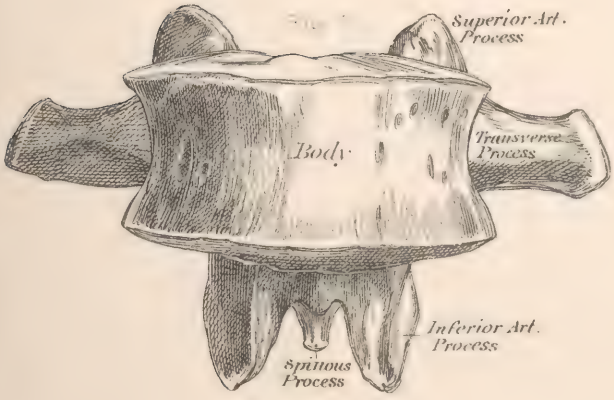


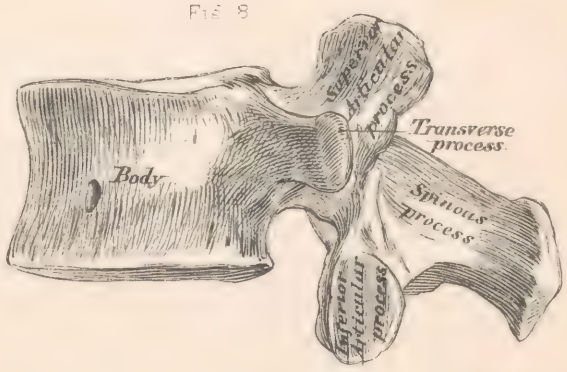












E. Sinclair & Son Lith.

sive and bifid, and beneath is grooved its entire length.

The *superior articular process* is placed near the base of the odontoid process. It is concave from side to side. Its outer half lies directly above the transverse process, projects in front, and faces upward.

The *inferior articular process* is not placed beneath the superior but upon the lamina. It is inclined upward, forward, and faces forward.

The *transverse process* is placed beneath the superior articular process. It extends abruptly downward and backward. The process is but faintly grooved above. Its foramen is directed outward.

Structure.—The cancelli are figured by Luschka as more compact in the odontoid process than in the body. Humphry describes and figures this compactness as decided. The denser part forms a division between the more cancellous apex and the rest of the process. K. Bardeleben[1] figures the process as almost entirely compact. Dr. C. T. Hunter has detected in the process a special arrangement of trabecular fibres beneath this compact tissue much weaker than those ordinarily met with in the interior of the other vertebræ. In the judgment of this observer the frequency of fracture at the neck is hereby explained. It is evident from the foregoing statements that the odontoid process is more compact than the rest of the axis, but that in the degree of its compactness and arrangement of the cancelli at its neck there is some variation.—Dr. Reid[2] has recorded an instance of conical exostosis of the odontoid process which induced compression of the spinal cord and death.

P. Devan[3] reports a case in which the odontoid process which had been separated from the body of the axis by fracture, had united to the edge of the foramen magnum, thus emphasizing the relation occasionally seen between these parts in the uninjured subject.

Remarks.—As an exceedingly rare formation the tip of the odontoid process may be prolonged upward and articulate with the anterior border of the foramen magnum. According to Luschka, the tip of the spinous process receives a distinct centre of ossification.

The neck of the odontoid process is the weakest part of the bone, and that portion which is most frequently the seat of fracture. Humphry[1] describes this as a very rare condition, he having seen but two examples.

[1] Beiträge zur Anatomie der Wirbelsäule, Jena, 1874, Faf. 1, fig. 23.

[2] Lond. and Edin. Journ. Med. Sci., 1843.

[3] Dublin Medical Press, Feb. 18, 1863.

THE SEVENTH CERVICAL VERTEBRA.

The seventh cervical vertebra presents the following peculiarities: The articular processes are almost vertical, are not supported by small columns, and do not lie directly one above the other. The foramen at its base does not transmit the vertebral artery. The body is without median projection. There is sometimes one-fourth of a facet for articulation with the head of the first rib. The lateral extension of the lower surface of the vertebra may be almost entirely absent. The spinous process is very large, resembles that of a dorsal vertebra, and is without a groove. While not bifid it is much larger than any other of the cervical series, and forms in the subject a distinct prominence beneath the skin. From this feature the bone has received the name of the "vertebra prominens." The process gives attachment to the nuchal ligament. According to Luschka the spinous process is often fractured. It was once so found by this observer in the body of an epileptic patient under circumstances suggestive of the fact that the lesion had occurred as the result of a fall during a convulsion.

Remarks upon the Cervical Vertebræ as a Whole.—The portion of the spine composed of the cervical vertebræ is at once the most flexible and most varied in form, while the most constant in the number of its elements.

The position of the cervical vertebræ can be made out in a satisfactory degree in the living subject. The fact that the anterior surfaces of the bodies lie directly behind the pharynx and the beginning of the œsophagus enables the finger to freely define the position of the second to fifth vertebræ through the posterior wall of the pharynx. The rounded nodule on a level with the base of the uvula is the atlas. It varies in degree of prominence. It is not to be confounded with a transverse fold of induration seen in the same neighborhood in certain abnormal conditions of the pharynx. The smooth surface directly in view when the mouth is open answers to the axis, which extends from the position of the nodule to the tip of the epiglottis. Behind the free portion of the epiglottis lies the body of the third vertebra; behind the fixed por-

[1] Loc. cit. 131.

tion of the cartilage, the fourth; behind the cricoid cartilage, the fifth and sixth. The atlas-nodule is always distinct in the adult; the remaining points are variable. In some subjects a uniform median keel-like ridge can be readily felt the entire length of the pharynx.

The formation of pus behind the pharynx is sometimes caused by diseased vertebræ; and in necrosis of the atlas and axis portions of these bones have been ejected into the pharynx (see Pharynx). In like manner, after fracture of the odontoid process, the detached fragment has been known to escape by perforation of the pharyngeal wall.

On the sides of the neck the transverse processes can be distinctly felt beneath the skin in emaciated subjects. The distance between the transverse process of the atlas and the angle of the lower jaw is not greater than half an inch. In dissection the process is not exposed until the anterior tendinous margin of the Sterno-Cleido-Mastoid muscle is raised from over it, the tough fibrous tissue is removed, and a deep-seated lymphatic gland which is lodged below the process is pressed aside. The process in reality belongs, clinically speaking, to the region about and behind the angle of the jaw. Its condition should be carefully eliminated in making a diagnosis of tumors of this region. H. J. Bigelow[1] believes that cystic tumors of the neck almost always arise from the parts about this transverse process and the styloid process of the temporal bone. The styloid process extends downward and forward one-third of an inch between the angle of the jaw and the transverse process. Further down the neck the transverse processes can be felt by deep palpation. They serve as valuable guides in making incisions for reaching the track of the great vessels in ligation, and for the position of the œsophagus in œsophagotomy.

Posteriorly the third, sixth, and seventh spines can alone be felt. The remaining spines are thickly covered by the soft parts. The apex of the lung answers to the spine of the seventh vertebra. It is about this spine that a peculiar neuralgic pain often radiates in anæmic persons.

Specimens are occasionally met with in the collections where the atlas and the skull become anchylosed. After fracture in this region the reparative process is active, so that union of the fragments takes place should the patient survive the immediate effects of narrowing of the vertebral canal.

The deformations arising from malposition of the vertebræ are to be carefully separated from those due to muscular contraction or wry neck.

F. R. Lente[1] has reported the rare anomaly of a vertebral column possessing but six cervical vertebræ.[2]

The Cervical Rib.—The anterior portion of the transverse process of the seventh vertebra bearing the anterior tubercle is sometimes imperfectly anchylosed to the body. When thus free it has received the name of the cervical rib, since it is homologous with a true rib. Its anterior extremity may be free or be joined to the first true rib. The presence of a cervical rib may interfere with the normal relations of the subclavian artery, diminish the circulation of the upper extremity, or induce pressure upon the brachial plexus. An exostosis growing from such a rib was detected by Holmes Coate[3] on the left side in a female aged 26. The condition was thought to be congenital, at least it had existed since early childhood. The growth was successfully removed by operation. The circulation of the limb remained unimpaired. The cervical rib has been the subject of special memoirs by Halbertsma,[4] Luschka,[5] Struthers,[6] Gruber,[7] and Turner.[8]

THE DORSAL VERTEBRÆ.

The dorsal vertebræ are the vertebræ of the chest or thorax. Each bone is distinguished by the presence on the side of the body of a depression for the head of its associated rib. The two upper dorsals resemble the type of the cervicals, the lower dorsals resemble the type of the lumbar vertebræ. Rudiments of the true transverse and mammillary processes are seen on the bodies of the eleventh and twelfth.

The *body*, figs. 5 and 6, Plate XIII., is narrower in front than behind. From the third to the eighth the bodies are convex in front and concave behind to

[1] Bost. Med. and Surg. Journ., vol. lxxxvii. 279.

[1] N. Y. Journ. of Medicine, 1850, 285.

[2] For an account of the homologies of the atlas, axis, and those of the occipital bone, in connection with these bones, see Cleland, Nat. Hist. Rev. Ap. 1861, also W. Allen, Journ. Anat. and Phys. xiv. 1879, 18.

[3] Med. Times and Gazette, Ap. 3d, 1861, 108.

[4] Roy. Acad. Sci. Amsterdam, 1856, 238.

[5] Denkschriften der m. n. Klasse der Kais. Acad. der Wissenschaften, Berlin, xvi.

[6] Ed. Monthly Med. Sci. xvii. 1853, 292.

[7] Mem. Acad. Imper. St. Petersburg, xiii. 1869.

[8] Journ. of Anat. and Physiol. iv. 1870, 130.

form the anterior border of vertebral foramen. In the last four the posterior surfaces are flat.

The transverse sections of the bodies of the upper and lower vertebræ exhibit oval figures, while those of the middle are triangular, with sub-rounded angles. The anterior surface of each body is sometimes called the *visceral* surface from its relation to the thoracic viscera, when the posterior becomes the *vertebral*, or *spinal* surface. The upper and lower surfaces are not parallel, but may be slightly inclined toward one another.

The *depression for the rib* is variable in shape, but is for the most part of a modified semilunar figure. The upper nine vertebræ have for this purpose two demi-facets, one at the upper at the junction of the body and the lamina, at the other at the lower border of the body near the vertebral border. In the eleventh and twelfth ribs the single facet is placed more upon the lamina than in the others.

The *pedicle* arises from the body at its upper half and at its side. While the lower border is rounded, the upper is sharp. At the same time the upper notch is shallow, and looks upward and inward, while the inferior is deep. In the first dorsal vertebra the pedicles are cylindrical. The upper notch is deep and semicircular, and looks upward.

The *laminæ* are broad and thin, and soon unite to form the broadly-based spinous process. At the pedicles the laminæ are horizontal; but beyond the superior articular process of each side the laminæ are deflected abruptly downwards on the same plane with that of the spinous process.

The superior articular processes are both nearly on the same plane with the laminæ, and look backward. *The inferior articular processes* look forward, excepting those of the twelfth vertebra, which look laterally. The so-called *transverse process* is a conspicuous robust projection, nearly as broad as the body. It is directed laterally and a little backward. Its anterior surface is rounded by a facet for articulation with the corresponding rib. The *true* transverse process, viz., that which is homologous with the posterior tubercle of the cervical vertebræ, is not seen in the dorsal vertebræ until the tenth and eleventh are reached as already mentioned. In the lumbar vertebræ they again appear.

THE DORSAL VERTEBRÆ AS A WHOLE.—When the twelve dorsal vertebræ are articulated they are seen to form a column whose anterior surface is concave. The spinous processes, notwithstanding their relatively great length, project not directly backward, but obliquely downward and backward. The laminæ thus overlap—less at the beginning and the end of the column than toward its middle. A degree of strength is thus secured to the dorsal region over and above that secured by the articular surfaces against one another, while the vertebral canal receives an additional protection. The ribs still further aid in protecting and fixing the dorsal region, which is as a result the best preserved from injury, while the most rigid, of any portion of the spine. Exostoses of the vertebral canal are rare. Humphry[1] mentions a case in which a bony outgrowth had projected from the hinder surface of one of the dorsal vertebræ and had pressed upon the cord, inducing paralysis of the lower extremities.

THE LUMBAR VERTEBRÆ.

The lumbar vertebræ are the vertebræ of the loins. Each bone (figs. 7 and 8, Plate XIII.) possesses a massive body, which is wider from side to side than from before backwards. Its nutritive foramina are more conspicuous than in other vertebræ. These are especially well developed upon the posterior surface, where they form two openings for the basi-vertebral veins upon either side of a faint median ridge. The latter is often absent, when the openings are confluent.

The *laminæ* are correspondingly massive with the body. The *pedicles* arise from the upper half or two-thirds of the body. They are short, but heavy, and support the transverse and superior articular processes. These latter structures may be studied in the following order: The *transverse process* (homologous with a rudimentary rib) arises from the outer side of the pedicle at the base of the superior articular process. It is broad and compressed laterally, and is directed outward and backward. The *superior articular process* presents a concave facet directed inwards and backwards. The outer surface of the process yields at its posterior border a rounded eminence projecting backward beyond the facet, the *mammillary process* for the origin of the slip of the Multifides Spinæ muscle. Behind the base of the transverse process is seen the *accessory process*, which is a faint ridge-like projection representing a rudiment of the transverse process of the dorsal vertebræ.

The *spinous process* is very broad, directed horizontally backward from the laminæ. It is thin above, broad below, whence its contours are continuous with the *inferior articular processes*. The latter are nearer

[1] Human Skeleton, 157.

one another than are the upper. They are deflected at a right angle from the lamina of its own side. The facets are vertical, slightly convex, and look outward and backward.

The *vertebral canal* is triangular, with sub-rounded angles, or is lozenge-shaped.

The curve of the lumbar column is very slight, and is so directed as to be convex forward. To this effect both the bones and the shapes of the intervertebral disks contribute.

Friction facets are often seen between opposed borders of the spinous processes, and occasionally a distinct interspinous joint forms. The fifth vertebra is deeper at the anterior than at the posterior margin. The transverse processes lie in a series with the lower so-called transverse processes and with the ribs of the dorsal vertebræ.

REMARKS ON THE VERTEBRAL COLUMN AS A WHOLE.

The applications to practice that can be made of a knowledge of the anatomy of the vertebral column are numerous and important.

It is necessary to remember that the spine is secured in position by the joints between the vertebræ. The variations of the shape of the column are due to the dispositions of the joints as well as of the bones.

Destruction of the bodies of the vertebræ so far interferes with the lines of support already mentioned as to throw the weight of the superimposed mass upon the laminæ. These are not adapted to sustain such weight, save only in the cervical vertebræ; and when, as is frequently the case, the dorsal vertebræ are involved, the drag of the ribs, sternum, and their muscular and visceral attachments create an exaggerated antero-posterior curvature of the dorsal vertebræ, ending in deformity not only at the portion of the spine thus yielding, but in others, so that a group of secondary changes in the entire vertebral column arise, distorting or obliterating the normal curves.

Roslan, according to Portal,[1] has found a greater tendency to displacement on the parts of the bones of the vertebral column to exist between the last dorsal and the first lumbar vertebra than elsewhere. Jeffries Wyman,[1] in reaffirming that the lumbar region is the weakest portion of the lumbar arch notwithstanding its increased bulk when compared to the other regions of the spine, uses the following language:—

"In dorsal vertebræ the arches are characterized by the breadth of the laminæ and by having the transverse processes implanted just between the articular ones, where, in consequence, the arch becomes greatly strengthened, in fact, has its greatest strength. In the lumbar region the transverse processes are thrown further forward, so as to rest more upon the pedicle, while the upper and lower articulating ones become more widely separated from each other, the lower ones being carried downwards, and the bone connecting them so contracted as to form a somewhat slender neck; thus the part in question becomes the weakest instead of the strongest portion of the arch."

Malgaigne, while recognizing the weak point above defined, gives two others, one at the junction of the cervicals and the dorsals, and the other at the junction of the lumbar vertebræ and the sacrum;—in a word, including *all* the vertebræ of transition.

Humphry has cited a number of related causes in explanation of the same group of facts. Since, for example, "the transverse processes being very short, while the long transverse processes in the lower part of the loin, added to the projecting crest of the ilium below, and the false and true ribs above, afford to the several muscles a powerful leverage acting upon this junction on either side and in front. It is near the middle of the column, so that a greater length of leverage can be brought to bear against it than at any other part."

The next weakest point in the vertebral column is the dorsal region. Fracture is relatively frequent here, and, as already stated, antero-posterior curvature of the spine is common.

Dr. D. J. Cunningham[2] has observed a vertebral

[1] Anat. Med. I. 295, note.

[1] Bost. Med. and Surg. Journ. 1869.

[2] Journ. Anat. and Phys. 1878, 89.

EXPLANATION OF PLATE XIV.

Fig. 1. The sacrum, seen from in front.

The reader should read the word "promontory" as referring to the anterior surface of the first sacral vertebra at its upper part.

Fig. 2. The sacrum, seen from the side.

Instead of "for sacral vertebra," read "1st sacral vertebra."

Fig. 3. The sacrum, seen from behind.

Fig. 4. The coccyx, seen from behind.

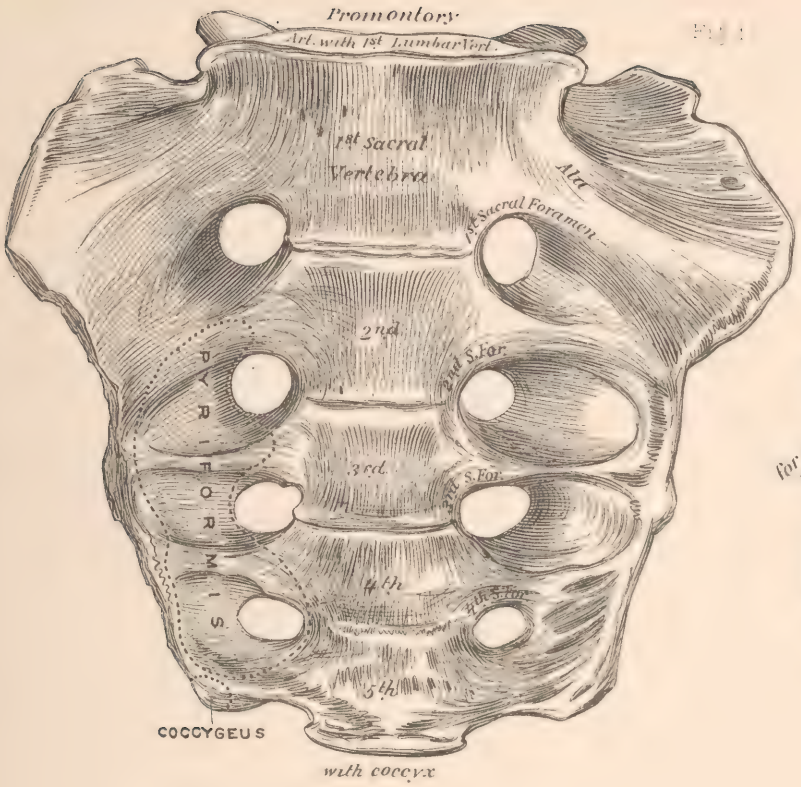


Fig. 1

with coccyx

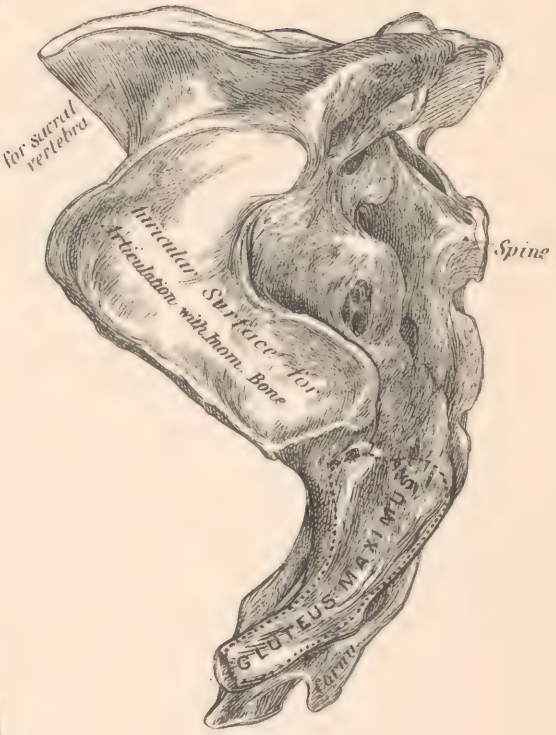


Fig. 2

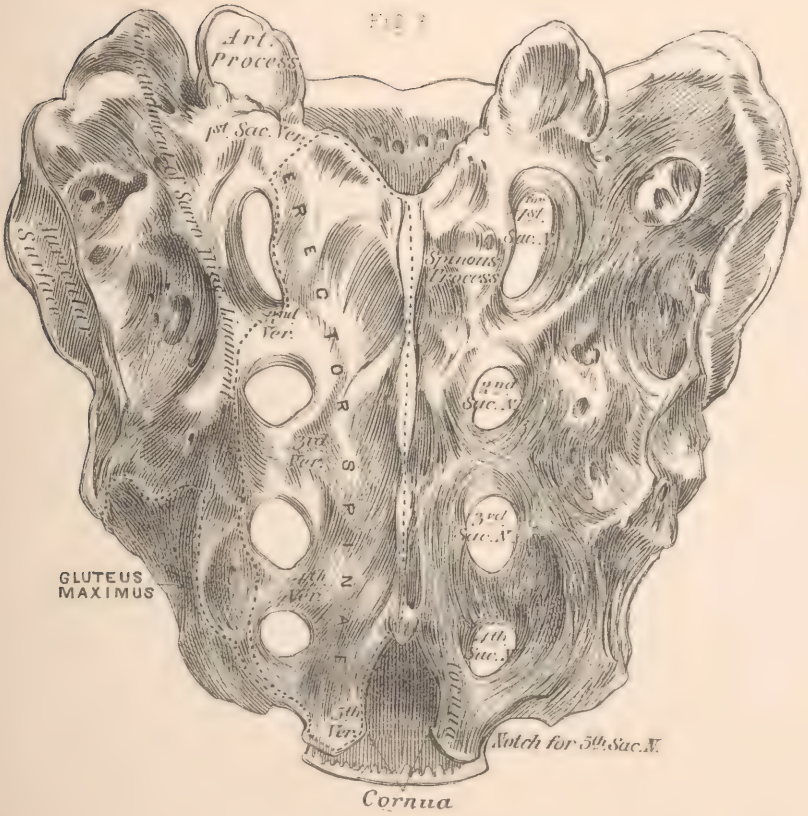


Fig. 3

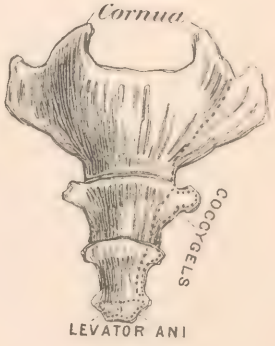


Fig. 4

column in which the epiphysial processes of the mammillary processes of the twelfth dorsal remained distinct; as also did the fused mammillary and accessory processes of the first lumbar vertebra. The spinous process of the first dorsal and the transverse process of the seventh dorsal in like manner presented detached epiphysial bones.

TABULAR PLAN OF PARTS OPPOSITE THE SPINES OF THE VERTEBRA. (Holden.)

CERVICAL.	7th. Apex of lung; higher in the female than in the male. (30)
DORSAL SPINES.	1st.
	2d.
	3d. Aorta reaches spine. Apex of lower lobe of lung. Angle of bifurcation of trachea. (49)
	4th. Aortic arch ends. Upper level of heart.
	5th.
	6th.
	7th.
	8th. Lower level of heart. Central tendon of diaphragm.
	9th. Œsophagus and vena cava through diaphragm. Upper edge of spleen.
	10th. Lower edge of lung. Liver comes to surface posteriorly. Cardiac orifice of stomach.
	11th. Lower border of spleen. Renal capsule.
	12th. Lowest part of pleura. Aorta through diaphragm. Pylorus.
LUMBAR.	1st. Renal arteries. Pelvis of kidney. (83)
	2d. Termination of spinal cord. Pancreas. Duodenum just below. Receptaculum chyli.
	3d. Umbilicus. Lower border of kidney.
	4th. Division of aorta. (65) Highest part of ilium.
	5th.

According to the same authority, the spine of the second dorsal corresponds with the head of the third rib; the spine of the third dorsal with the head of the fourth rib; and so on until we come to the eleventh and twelfth dorsal vertebræ, which so tally with their corresponding ribs.[1]

[1] For other relations, see Tabular Relations between the anterior and posterior surfaces of the thorax.

THE SACRUM.

The sacrum (figs. 1, 2, 3, Plate XIV.) is formed by the fusion of the five vertebræ which intervene between the lumbar vertebræ and the coccyx. The lines of union of the bodies of the vertebræ can be distinguished in front by four transverse ridges representing the position of the ossified intervertebral disks; and behind by a median row of tubercles which represent the dorsal vertebral spines. The intervertebral foramina are seen under the name of the *sacral foramina;* and the vertebral canal under the name of the *sacral canal.*

The sacrum is the broadest part of the vertebral column, and forms the posterior wall of the pelvis. The bone has been compared to a wedge. Its anteroposterior curvature impairs the value of this figure somewhat. The first sacral vertebra closely resembles the last lumbar vertebra both in appearance and in size; the remaining segments gradually lose resemblance to vertebræ, the last, indeed, retaining little beyond a body and imperfect laminæ.

The sacrum presents for examination a base, an apex, and anterior, posterior, and lateral surfaces.

The *base* has a broad surface, which corresponds to the body of the last lumbar vertebræ, and a pair of well-defined sacral articular processes which join the inferior lumbar processes of the same name. The *apex* is small, and articulates with the coccyx by a narrow oval surface.

The *anterior surface* (fig. 1, Plate XIV.) is concave and nearly smooth. It is ridged transversely by the four lines of union between the several vertebræ. The spaces between the terminations of these ridges and the lateral surfaces are called the *lateral masses*, and are marked by four broad and shallow grooves for the anterior sacral nerves. The anterior upper portions of the sacrum are often spoken of as the wings or *alæ*. The Pyriformis muscle arises from the lower two-thirds of the lateral mass, and the Coccygeus arises in part from its inferior portion.

The *posterior surface* (fig. 3, Plate XIV.) is narrower and more irregular than the anterior. The laminæ, dorsal spines, articular and transverse processes unite with one another without suture, thus covering in the sacral canal except at a small space behind the first and last sacral vertebræ, where, as a result, the *superior* and *inferior sacral notches*, respectively, are defined. The laminæ blend to form a continuous surface on either side of the median row of tubercles which are the rudiments of the dorsal spines. This surface would be smooth throughout, were it not for the nodosi-

ties which stand for the pairs of coalesced articular and mammillary processes of the sacral vertebræ. They are ranged in a linear series between the more conspicuous dorsal spines and the posterior sacral foramina. The terminations of the line of articular processes form noticeable projections; the inferior of these are called *the sacral cornua*. To the outer side of these foramina are placed the less perfectly marked remains of the lumbar transverse processes. By reason of these numerous modifications of the vertebræ, the vertebral grooves are shallow and imperfectly defined. The posterior sacral foramina are much smaller than the anterior, and are not accompanied with grooves. The posterior surface gives origin to the Gluteus Maximus and Coccygeus muscles, and to the vertebral aponeurosis.

The *lateral surfaces* (fig. 2, Plate XIV.) are divided into two portions, which differ widely in their degrees of departure from the vertebral plan. Each surface answers to the sides of the first three vertebræ, is broad and thick, and in the fresh condition of the bone is occupied by an ear-shaped surface of cartilage (*auricular surface*) for articulation with the corresponding innominate bone. Below the auricular surface the lateral surface is compressed, notched, and without articulation. Above, it affords attachment to the sacro-sciatic ligament.

Viewed as a portion of the spinal column the sacrum presents an abrupt anterior convexity opposite the first sacral vertebra, called the *promontory* of the sacrum. This eminence may so vary as to be opposite to the second sacral vertebra. Below this is a gentle concavity, which assists in forming the superior outlet of the pelvis, and in supporting the pelvic viscera.

In uniting with the lumbar vertebra an opening of variable size is formed between the laminæ of the vertebræ and the first dorsal tubercle of the sacrum. Hence the vertebral canal is not well protected at this point. When from any defect in the development of the posterior surface this opening is preternaturally large, we have the condition known as spina bifida. Spina bifida may in this way be confined to the upper portion of the sacrum, or it may involve the entire bone and even the lumbar vertebræ. In addition to the above the union converts the supra-intervertebral notch into a foramen of the same name. Union with the coccyx converts the intervertebral notch at the lower border of the sacrum into a foramen; and union with the innominate bone converts the notch at the lower border of the lateral surface into a foramen which transmits the fifth sacral nerve.

Development.—The sacrum develops after the manner of the vertebræ, of the elements of which indeed it is composed. Thus there is one centre each for the bodies of the vertebræ, and one each for the laminæ posteriorly, as well as for the tubercles which answer to the mammillary tubercles of the lumbar vertebræ. Epiphyses, similar to those seen elsewhere in the vertebral column, arise upon the bodies of the vertebræ. In addition to these vertebral characteristics the sacrum presents a new ossification upon its lateral surfaces. These are two in number on each side, and resemble generally the epiphyses upon the vertebræ. The following is the order in the development of the parts of the sacrum:—

Ossification takes place in the bodies and laminæ at the eighth or ninth week; the laminæ begin to ossify at the sixth month; the union of the laminæ with the body in the lower vertebræ occurs in the second year, and in the upper later, namely, at about the fifth or sixth year. The epiphysial and lateral plates are formed at the sixteenth year, and completed at the twenty-fifth. The bodies of the sacral vertebræ unite slowly. The process is completed from below upward, as with the laminæ, at about the twenty-fifth year. (Quain.)

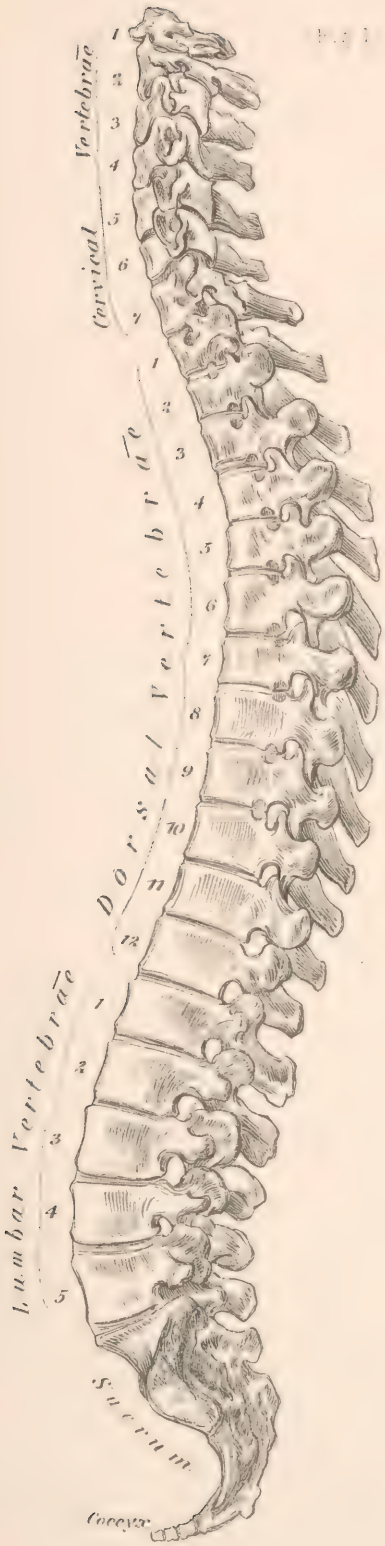
Articulations.—The sacrum articulates with the last lumbar vertebra above, the coccyx below, and the innominate bones at the sides.

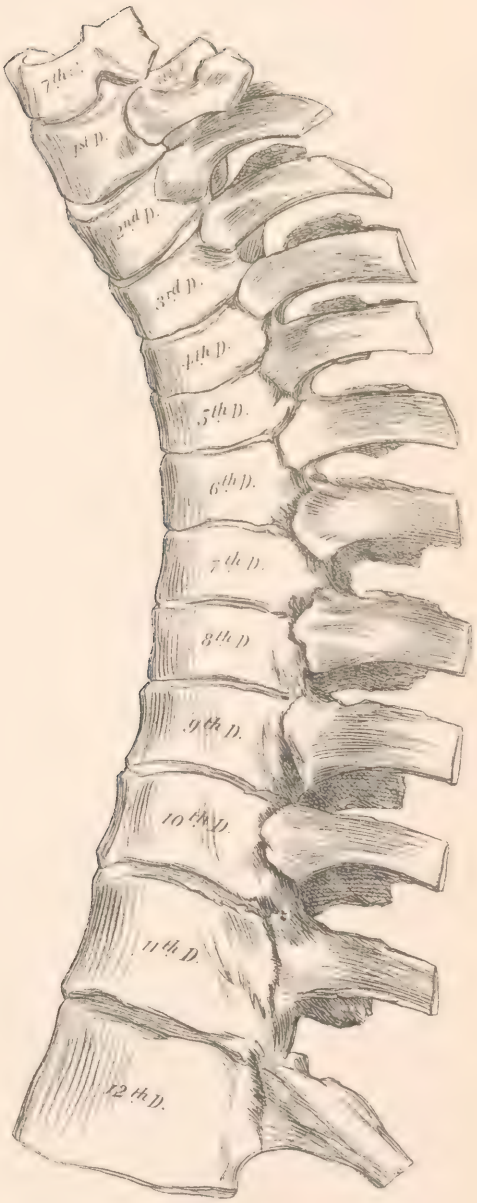
Remarks.—The promontory of the sacrum can be readily felt by rectal examination.

EXPLANATION OF PLATE XV.

Fig. 1. The vertebral column, seen from the side.

Fig. 2. The dorsal vertebræ and portions of ribs in position, showing the method of union between the ribs and the vertebræ. From a dried preparation. The curve of the column is distorted, and the lines of union of the heads of the ribs with the vertebræ are too irregular.





T. Sinclair & Son, Lith.

The base of the sacrum is about on the level of the anterior superior spinous processes; the position of the promontory can thus be accurately determined.

THE COCCYX.

The coccyx is composed of the rudiments of four vertebræ. This number may be increased to five, or even be reduced to three. The coccyx has neither arches nor spinal canal. The bones arrange themselves in a series resembling that seen in the sacrum, inasmuch as the first is the largest, and the last is the smallest: the resultant figure is therefore wedge-shaped. The first vertebra is usually distinct, while the remaining are co-ossified, the limiting ridges alone indicating the lines of union. The first vertebra possesses a pair of ascending processes (*the coccygeal cornua*), posteriorly, which are in the line with the articular processes of the sacrum, and which may be considered to be rudiments of the laminæ. Well-defined rudiments of transverse processes exist in this member of the series alone.

The second and third coccygeal vertebræ are much compressed from above downward, and triangular in form; while the remaining portion of the bone is pyriform. The first coccygeal vertebra unites with the second, and also with the sacrum in the adult period. Such union is subject to much variation. An intervertebral disk exists ordinarily between the coccyx and the sacrum.

DEVELOPMENT.—The coccyx arises from four centres of development. Ordinarily each bone arises from a distinct centre; the upper may arise from two. The first becomes osseous at birth; the second at from the fifth to the tenth year; the third before puberty; and the fourth after puberty.

REMARKS.—The coccyx can be readily felt by rectal or even vaginal examination. It has been often fractured by external violence; and in parturition, where marked sacral curvature exists, it is often either fractured or displaced. The greatest interest centring about the coccyx relates to the painful affection known as coccygodynia. In connection with the structural changes associated with this disease the student should carefully study the ligaments and nerves of the coccyx, and the muscles inserted into it, as well as the position of the coccygeal body. Among the causes of this affection may be mentioned inflammation of the bone and ligaments, contracture of the muscles, and enlargement of the coccygeal body. Verneuil[1] proposes to remove the coccyx as a preliminary procedure to perineal section in cases of imperforate rectum. The assertion is made that the operation is without danger.

For the relation existing between the curvature of the sacrum with the coccyx and the genital cleft, see the account of the female organs.

THE BONES OF THE HEAD.

The skull is composed of two sets of bones: one defines the brain-case and constitutes the *cranium* proper; and the other defines the nasal and orbital cavities, at the same time affording protection to the teeth, and constitutes the *face*.

The bones of the cranium are eight in number,—

The occipital,	The two parietals,
The two temporals,	The frontal,
The sphenoid,	The ethmoid.

The bones of the face are fourteen in number,—

The vomer,
The two superior maxillæ,
The two palatals,
The two inferior turbinated bones,
The two malars,
The two lachrymals,
The two nasals,
The inferior maxilla.

All the bones of the head, with the exception of the inferior maxilla, are immovably united together.

THE OCCIPITAL BONE.

The occipital bone (figs. 1, 2, 3, Plate XVI.; also, fig. 2, Plate XXXVI.) is situated at the base and posterior part of the cranium. It is slightly curved from above downward, and seen in profile is of a crescentic figure. The part of the figure in advance of the conspicuous condyles passes upward and forward, and forms the *basilar portion* of the bone; that to the outer side of the condyles forms the *lateral portion;* and that behind, passing backward and upward, forms the *ascending portion.* Between the condyles, and extending thence backward, lies the *foramen magnum.* This is a large oval foramen, somewhat longer than wide, and wider behind than in front.

The occipital bone articulates with the sphenoid bone and with the parietal and temporal bones. It affords

[1] Gaz. des Hôpitaux, Nos. 87 and 90, 1873.

protection to the cerebellum and the occipital lobes of the cerebrum within, and yields points of origin to important bones without. In advance of the condyles it assists in forming the roof of the pharynx; and behind in defining the occiput and post-atlantal space. The foramen magnum transmits the medulla oblongata, the vertebral arteries, and the spinal accessory nerves. These structures do not entirely occupy the opening, the space between the medulla and the margin being filled by the cerebro-spinal fluid.

The *basilar portion* of the occipital bone is an oblong figure, and abruptly truncate in front, where it joins the body of the sphenoid bone. It is wedge-shaped—the base of the wedge constituting the surface that articulates with the body of the sphenoid, the edge forming in great part the anterior margin of the foramen magnum. The basilar process presents four surfaces for examination: an anterior and a posterior, just mentioned; a superior, which is concave and smooth to receive the medulla oblongata and the basilar artery; and an inferior, which is more irregular, and which is marked as follows: from before backward, first by a median minute circular depression, not constantly present; second, by the *pharyngeal tubercle* for the attachment of the pharyngeal aponeurosis; third, by the symmetrical depressions directly in advance of the occipital condyles, for the Anterior Recti muscles. The lateral (outer) surface of the basilar portion is uneven, and articulates at its upper portion with the petrous portion of the temporal bone. Seen in position in the skull, the greater part of the under surface of the basilar process is free, and is covered by a dense fibrous tissue during life.

Each *lateral portion* is joined anteriorly by the basilar, superiorly by the ascending portion of the bone. It joins externally the mastoid portion of the temporal bone. Upon its lateral side is a deep depression, the *jugular notch* which receives the jugular vein. Directly in front of the jugular notch is seen a smaller excavation for the ninth, tenth, and eleventh pairs of nerves. At the beginning of the occipito-mastoid junction is a broad *transverse process* (jugular process), which is tipped in the recent subject with cartilage. Upon the under surface of the lateral portion, and corresponding at the same time to the under surface of the transverse process, is the *jugular tubercle*, for origin of the Rectus Lateralis muscle. Upon the under surface in front of the condyle lies the *anterior condyloid fossa*, which is pierced by the *anterior condyloid foramen* (hypoglossal canal) for the transmittal of the hypoglossal nerve. Behind the condyle is seen a depression (*posterior condyloid fossa*), which is commonly perforated by the smaller *posterior condyloid foramen* for the accommodation of the posterior condyloid vein. The superior surface of the lateral portion is marked by the lateral sinus, as it passes downward to empty into the internal jugular vein. Upon the encranial surface and over the course of the anterior condyloid foramen is seen a bridge of bone, called the *jugular eminence.* — The large *occipital condyles* are placed one on each side of the foramen magnum. The articular surface of each condyle is elliptical in form, and directed obliquely downward and inward. The anterior edge of the articular surface rests on a rounded border that is angulated to the plane of the anterior condyloid fossa and that of the basilar process. The posterior portion of the articular surface lies on a level with the posterior condyloid depression, and thus presents a marked contrast to the anterior. The inner surface of each condyle is uneven for attachment of the check ligaments. Each articular surface is composed of two facets of about equal dimensions, an anterior and a posterior. These facets are occasionally separated by a transverse groove.

The *ascending portion* of the occipital bone is a scallop-shaped expansion. It is convex externally, concave internally. The borders are thickened, and articulate by serrated surfaces with the parietal and temporal bones. The ascending portion joining

EXPLANATION OF PLATE XVI.

Fig. 1. The occipital bone, seen obliquely from the side.
Fig. 2. The occipital bone, seen from beneath.
Fig. 3. The occipital bone, seen from in front.
Fig. 4. The temporal bone, seen from beneath.
Fig. 5. The temporal bone, seen from median aspect.
The petrous portion is represented as foreshortened from in front.
Fig. 6. The temporal bone, seen from lateral aspect.
The words "Ext. Auditory meatus," should not have been engraved in capitals.


Sup. Angle
with parietal
lateral angle
with temporal
Squamous portion
Zygom. process
Jugular foramen
with occipital
Ant. condyloid foramen
Condyle
Angular tubercle

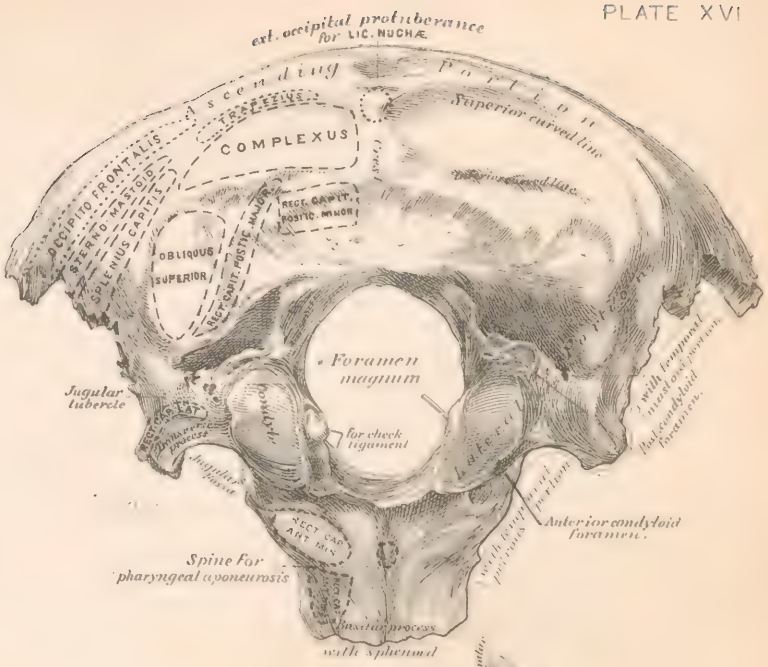
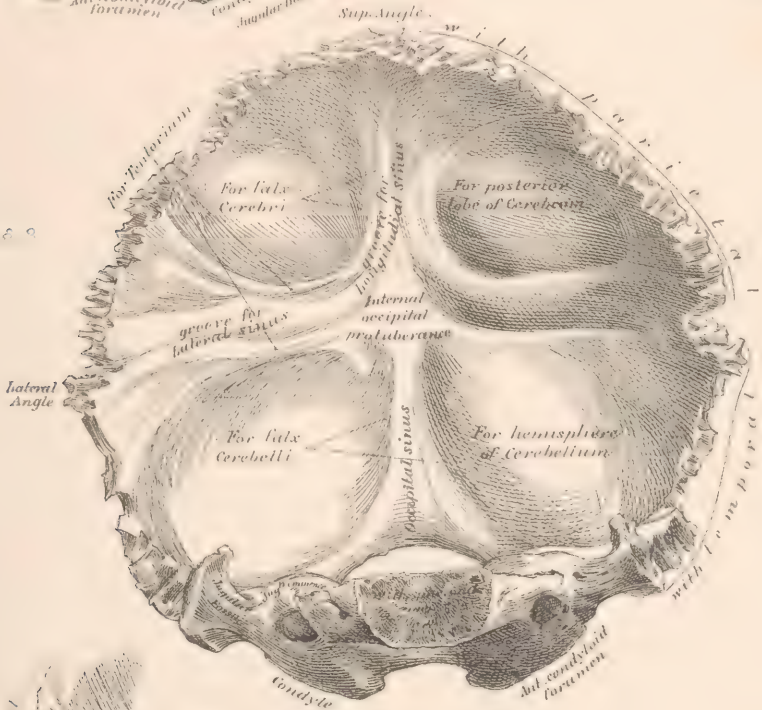
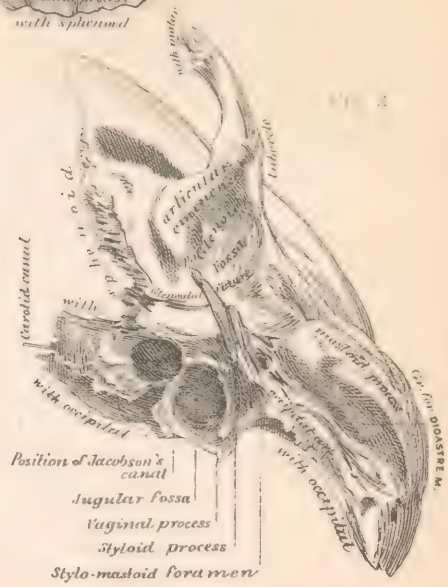

ext. occipital protuberance
for LIC. NUCHÆ
Superior curved line
COMPLEXUS
OCCIPITO FRONTALIS
STERNO MASTOID
SPLENIUS CAPITIS
OBLIQUUS SUPERIOR
RECT. CAPIT. POSTIC. MINOR
RECT. CAPIT. POSTIC. MAJOR
Foramen magnum
Jugular tubercle
for check ligament
Lateral portion
with temporal
Anterior condyloid foramen
Spine For pharyngeal aponeurosis
with sphenoid

Fig. 2


Sup. Angle
with parietal
Post. Fossa
For Tentorium
For falx Cerebri
For posterior lobe of Cerebrum
groove for Longitudinal Sinus
groove for lateral sinus
Internal occipital protuberance
lateral Angle
For falx Cerebelli
For hemisphere of Cerebellum
Occipital sinus
with temporal
Condyle
Ant. condyloid foramen


with malar
articular eminence
Fossa
Carotid canal
with parietal
with occipital
Position of Jacobson's canal
Jugular fossa
Vaginal process
Styloid process
Stylo-mastoid foramen

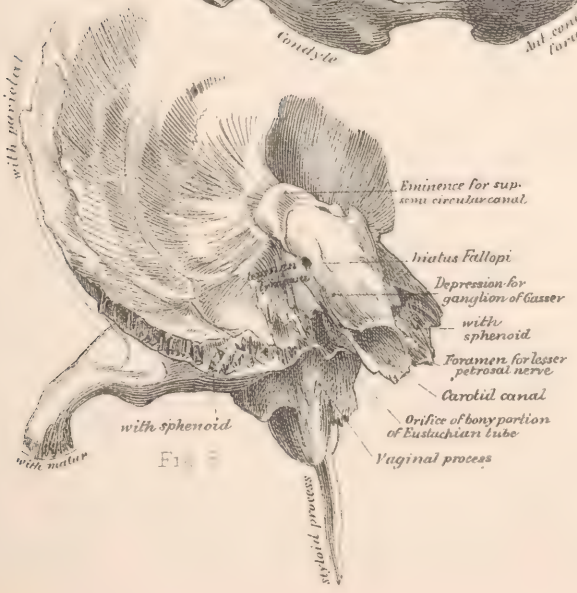
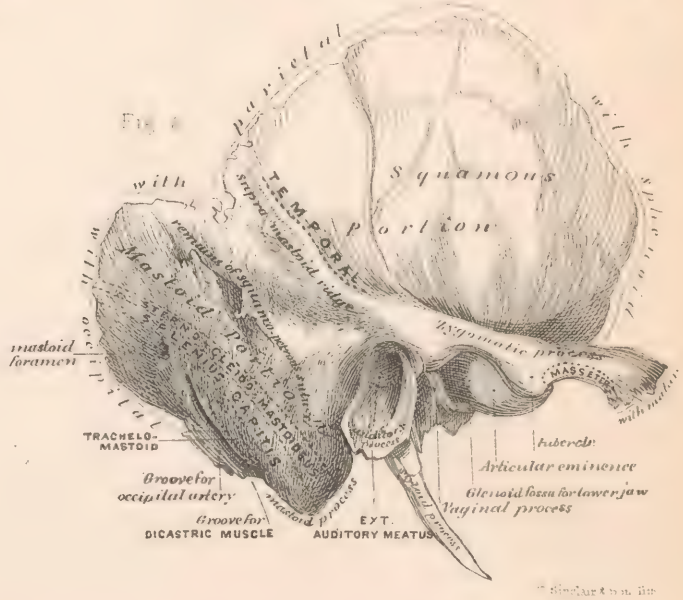

with parietal
Eminence for sup. semi circular canal
Hiatus Fallopii
Depression for ganglion of Gasser
with sphenoid
Foramen for lesser petrosal nerve
Carotid canal
Orifice of bony portion of Eustachian tube
with sphenoid
Vaginal process
with malar
Styloid process

Fig. 3


with parietal
Squamous portion
with temporal
supra mastoid ridge
remains of squamo petrosal suture
Mastoid portion
SPLENIUS CAPITIS
STERNO CLEIDO MASTOID
Zygomatic process
MASSETER
with malar
mastoid foramen
with occipital
TRACHELO-MASTOID
Tubercle
Articular eminence
Glenoid fossa for lower jaw
Vaginal process
Groove for occipital artery
mastoid process
Groove for DICASTRIC MUSCLE
EXT. AUDITORY MEATUS

the parietals behind the sagittal suture has received the name of the occipital *angle*, and the portion occupying the space between the two parietals the *interparietal* portion. On the external surface, a little less than midway between the base and the angle, is seen the *external occipital protuberance* for the attachment of the ligamentum nuchæ. It may form a conspicuous triangular process projected downward. The surface above the protuberance is smooth, and is curved in the subject by the aponeurosis of the Occipito-Frontal muscle; the surface below it is more uneven, and is marked by muscular impressions pertaining rather to the basal region of the skull. Extending from the occipital protuberance downward is a faintly defined ridge, *the occipital crest*. On either side of the crest are strongly marked impressions for the Complexus muscles. Bordering these above lies the *superior curved line* for the attachment of the Trapezius, Occipito-Frontalis, and the Sterno-Cleido-Mastoideus muscles. On a level with the Complexus impressions, but external to them, lie the planes of origin of the Splenius Capitis and Obliquus Superior muscles. The inferior margin of the Complexus impression is known as the *inferior curved line*. The space between it and the foramen magnum is occupied by the Rectus Capitis Postici muscles.

The internal surface (fig. 3, plate XVI.) of the ascending portion is deeply concave and smooth. At a point nearly corresponding to the external occipital protuberance lies the *internal occipital protuberance*. Passing thence downward, a little to the right of the median line is seen the groove for the great longitudinal sinus as it assumes a more horizontal position to form the groove for the lateral sinus. A fainter groove on the opposite side answers to the left lateral sinus. A smaller and inconspicuous sulcus for the occipital sinus extends from the protuberance downward to the foramen magnum, in approaching which it is apt to bifurcate. The large depressions on either side of the median line above and below the grooves for the lateral sinuses form collectively the *occipital fossa*. The upper two depressions receive the posterior lobes of the cerebrum; the lower receive the hemispheres of the cerebellum.

Structure.—The basilar process of the occipital bone from the margin of the foramen magnum to nearly half its length is composed of compact tissue; beyond this point it divides into an upper and a lower plate, of which the lower is the thicker: the space between the plates is occupied by cancelli. The lateral portions are for the most part spongy, and indeed in the aged the region of the jugular process becomes hollow. The ascending portion above the superior semicircular line is thick, and furnished with abundant diploë. It is thickest toward the occipital angle. Below the internal occipital protuberance, on either side of the occipital groove, the bone is thin and compact.

Development.—The occipital bone arises from seven centres. The basilar and lateral portions exist as cartilage prior to ossification. Ossification begins at about the seventh or eighth week; thus recalling the period at which the osseous centres appear in the bodies and the laminæ of the vertebræ. A little earlier the ascending portion of the bone, which is membranous, yields four centres of ossification, two on either side. These soon unite toward the centre to form the ascending portion of the bone, but leaving pronounced fissures extending inward from the periphery. At birth the bone is composed of the ascending portion, of the lateral or exoccipital portions, and of the inferior or basilar portions. The ascending and lateral portions join at about the second and third year; the basilar and lateral portions by the fifth or sixth year. The basilar portion unites with the body of the sphenoid bone between the fourteenth and the twentieth year.

The suture between the lateral and ascending parts near the posterior border of the condyles begins to be obliterated at the end of the first year. At the end of the second the obliteration is nearly complete—a small fissure at the border of the foramen magnum often persisting until the seventh year. It is rare for the entire suture to remain open during this time. The anterior portion of the interoccipital persists quite constantly until the seventh year.

Remarks.—The occipital bone is the most variable of any in the skull. The entire interparietal portion often projects backward from the vault-curve, and constitutes a frequent variety of cranial deformity. The angular process sometimes assumes the form of a distinct bone. Portal alludes to the fact that, in injuries of the skull, this portion has been known to be depressed and to impinge upon the meninges.—A conspicuous tubercle on the anterior margin of the foramen magnum is occasionally seen. In about one per cent. of crania the odontoid process of the axis secures an articulation with a facet on the anterior margin of the foramen magnum; this facet is termed the *tertiary condyle*.—The interparietal portion may contain a large

foramen in the median line, which may be assumed to answer to defective nutritive processes at the line between the first upper pair of centres of ossification of the ascending portion.—The entire angle may be defective, and may permit a hernia of the cerebrum to occur through the opening. It is interesting to note that in a case of this kind, recorded by Detmold,[1] a median depression existed in the hernial mass; this answered in position to the falx cerebri, which thus aided in modifying the shape and limiting the degree of the projection of the hernia.

The surface occupied by the jugular tubercle is the seat occasionally of a peculiar hypertrophy, which, occupying as it does the position of the paramastoid process in the lower animals, may receive this designation. The *paramastoid process* will sometimes appear in aged persons, where, from the fact that it is occupied by a few coarse cancelli, and that it thus resembles lung structure, it has received the name of the *pneumatic process*. The presence of the paramastoid process may induce one of the varieties of wry neck,[2] especially when it is attached to the transverse process of the atlas.

That the roof of the pharynx, which in the living subject answers in position to the basilar process, can be reached by passing a straight instrument through the nose, is a clinical test easy of demonstration. Winslow refers to a charlatan's trick of introducing a long nail through the nasal chamber as far as the basilar process, and attaching to the outer end of the nail a heavy weight. The process in this trial of strength acts as a point of resistance to the extremity of the lever, and is enabled from the direction of the pressure to bear the weight.—The basilar process may be easily pierced from beneath by a missile or other foreign body introduced through the nose or mouth. Of this injury the following case is a striking example: A little girl fell down while holding a wooden crochet-needle in her mouth. The needle transfixed the uvula, passed through the basilar process directly in front of the foramen magnum, and made a punctured wound of the medulla oblongata. Death ensued in three days.[3]—Caries of the basilar process has been diagnosed by Paget[4] in a male twenty-seven years old. An abscess formed at the nape of the neck, through the cavity of which a sequestrum from about the foramen magnum was removed. Through pressure upon the hypoglossal nerve the tongue was atrophied and deflected. The patient recovered.—Dupuytren[1] describes a case in which a hydatid cyst was lodged within the hypoglossal canal, causing symptoms similar to those of the previous case.—The foramen magnum may be either compressed laterally or greatly widened. There is preserved in the Musée Dupuytren a skull of an infant in which the foramen magnum is sufficiently large to have permitted a hernia cerebelli to appear upon the neck—a fact of unusual interest, since the tumor was mistaken for a cystic growth, and opened, with a fatal result.—In rachitis, the lateral portions of the occipital bone become flattened, forming a condition termed by Elsaesser the soft occiput.—Solborg[2] found in nine cases of epilepsy a constriction of the spinal canal, from hypertrophy of the jugular process of the occipital bone and of the posterior necks of the atlas and axis, with secondary atrophy of the medulla oblongata.

[1] N. Y. Journ. of Medicine, 1856, xvi. 77.

[2] C. F. W. Uhde, Archiv für Klinische Chirurgie, 1867, 24, Tab. 1, Literature.

[3] P. I. Kendrick, Med. Times and Gazette, 1867, 585.

[4] Trans. Clin. Soc. London, iii. 283.

THE TEMPORAL BONE.

The temporal bone (figs. 4, 5, 6, Plate XVI., also fig. 4, Plate XXII.) is situated at the side and base of the cranium, having the lateral portion of the occipital bone behind, the great wing of the sphenoid in front, the axis of the cranium within, and the temporal fossa, for the most part, without. Beneath is an irregular surface marked by the mastoid, styloid, and vaginal processes, and the glenoid fossa.

The bone, as generally described, presents for examination the squamous, the petrous, and the mastoid portions, but the significance of its several divisions cannot be in this way explained. It is better to divide the bone into parts that answer to the developmental centres. These are four in number, viz., the squamous, the petrous, the tympanic, and the styloid portions. To these may be added a fifth, the mastoid portion, for although the latter is not a true division of the bone (composed, as it is, of elements obtained from the squamous and the petrous portions), it is expedient to retain the term.

The *squamous portion* (squama) is the most conspicuous of these divisions when the bone is viewed in position from without.

Externally the squamous portion is composed of the squama, or ascending part, the zygomatic or horizontal part, and the glenoid fossa. The squama forms the greater part of the temporal fossa. It is

[1] Leçons Orales, i. 493.

[2] Rosenthal, Diseases of the Nervous System, ii. 63.

received in front by the greater wing of the sphenoid bone, above by the parietal, and is limited behind by the ridge forming the posterior margin of the temporal impression, viz., the *supra-mastoid ridge*. The squama is smooth, slightly convex, and covered in the subject by the temporal muscle. The zygomatic or horizontal portion lies upon the base of the skull. The *glenoid fossa* is a depression for articulation with the lower jaw. It lies upon the base of the skull, and is defined in front by a faint ridge, behind by the *glenoid fissure* (*squamoso-tympanic suture*), and by a dependent ridge, the *post-glenoid process*. From the junction of the squamous and zygomatic surfaces arises a large process called the *zygomatic*. This has a broad triangular origin from three roots. Its large posterior root is continuous with the post-glenoid process, its short anterior root is lost in the zygomatic surface, while its third, less defined, is received upon the under surface of the base of the process in a conspicuous convexity, *the articular eminence*. The zygomatic process extends horizontally forwards to articulate with the zygomatic process of the malar bone, and to form the zygomatic arch. The Masseteric muscle arises in part from this process.

Internally, the squamous portion is concave, and marked by several inequalities designed to give increased strength to the bone. It is grooved for the meningeal arteries, and receives the middle lobe of the cerebrum. Inferiorly an eminence is seen corresponding to the glenoid fossa.

The *petrous portion* is of an irregular pyramidal figure, the base of which is directed outward, the apex forward and inward. It is composed for the most part of very compact tissue, from which it derives its name. It contains the internal ear, transmits the facial nerve and internal carotid artery, and supports in part the cartilaginous portions of the Eustachian tube. It presents for examination three surfaces, an anterior and a posterior, which lie within the cranium, and an inferior, which lies at the base without.

The anterior surface is divided into two sub-equal areas. The upper portion is of petrous consistency, and corresponds to the bony covering of the labyrinth. It is marked as follows: (1) An eminence for the vertical semicircular canal; (2) A depression toward the apex for the ganglion of Gasser; (3) A small depression entering into the formation of the foramen caroticus internus. The lower portion is a thin layer of bone (*tegmen tympani*), which covers in the tympanum and forms the roof of the bony portion of the Eustachian tube. It is continued forward to the *squamoso-petrosal fissure*, and appears beneath at the glenoid fissure. The roof of the tympanum is perforated by one or more minute openings, the most conspicuous of which is the *hiatus Fallopii*, for the greater petrosal nerve, and a smaller one for the lesser petrosal. At times a clot of blood occupying the chamber of the tympanum will be evident (after the removal of the brain) by the bluish discoloration of the tegmen.

The posterior surface is less oblique than the anterior, and presents a division into two planes: an outer, which is marked by a small foramen directed outward, the *aquæductus vestibuli*, which transmits venous blood from the internal ear; and an inner, which is nearly continuous with the plane of the basi-cranial axis. The latter is marked by the *internal auditory meatus* for the passage of the seventh and eighth cranial nerves. Upon the ridge between the anterior and posterior surfaces is a groove for the superior petrosal sinus, which extends in a straight line as far as the *internal auditory meatus*, from which point it is deflected forward. From the meatus to the end of the petrous portion, the ridge is depressed for the reception of a thick fold of dura mater, beneath which pass the third, fourth, fifth, and sixth nerves. A distinct ossicle is occasionally found in this fold.

The inferior surface (fig. 3, Plate XXIV.) of the petrous portion is covered in part by the tympanic and styloid portions. As seen from the base of the skull, the petrous portion presents a posterior border for articulation with the occipital bone, marked from without inward by the following parts: First, by a smooth triangular surface directly behind the styloid process for articulation with the transverse process of the occipital bone. Second, by a semicircular sulcus (the *jugular groove*), which in articulation with the occipital bone forms the jugular foramen. Third, by a small notch for the reception of the ninth, tenth, and eleventh cranial nerves. Fourth, by an irregularly serrate border for articulation with the basilar process of the occipital bone, and by a small surface at its inner extremity with the body of the sphenoid bone.—The following parts are seen on the inferior free surface: First, a smooth space lying between the preceding and the inferior orifice of the carotid canal. Second, the floor of the carotid canal. To the outer side of the inferior surface is seen the large circular orifice of the canal, and to its inner side (the bone being in articulation), the median lacerated foramen. Near the basilar process of the occipital bone it is

roughened for the attachment of the pharyngeal aponeurosis; anteriorly it is smooth for the reception of the cartilaginous portion of the Eustachian tube.

The *tympanic portion* of the bone lies wholly upon its under surface. It is of an irregular shape, and composed entirely of compact tissue. When studied from without it presents a U-shaped portion wedged between the mastoid and the post-glenoid processes, limiting three sides of the large opening leading to the *external auditory meatus*, and thence to the tympanic membrane. The fourth and upper side of the meatus is formed by the squama. The curve of the U is much roughened, and produced downward. The tympanic division extends inward, and is seen on the base of the skull as a narrow compressed lamina, which insheathes the base of the styloid portion. Hence this aspect is called the *vaginal process*, which may be said to limit the glenoid region posteriorly. It is concave for the reception of the post-mandibular portion of the parotid gland. It terminates somewhat abruptly in a point opposed to the spinous process of the sphenoid bone at the beginning of the sulcus for the cartilaginous portion of the Eustachian tube. In narrow long skulls this point is often produced downwards as a spine. The floor of the external auditory meatus answers pretty nearly to the level of the base of the skull.

The *styloid portion* is composed of two separate pieces—the styloid and the tympano-hyal. The *styloid* is an elongated cylindroid spine, having an average length of an inch, and arises directly behind the vaginal process. It gives origin to the styloid group of muscles and to the stylo-hyoid ligament. The *tympano-hyal* is an unimportant ossicle placed between the base of the styloid and the stylo-mastoid foramen.—The styloid process may attain great length, when it will complicate a dissection for removal of tumors of the side of the neck.

The *mastoid portion*, seen from without, lies between the supra-mastoid ridge and the masto-occipital and masto-parietal borders. It is composed of spongy and compact tissue, and is derived from an extension outward of the primordial petrous portion joined with an outward extension of the squama. It is divided into a mastoid and a post-mastoid region by the lateral extension of the superior semicircular line of the occipital bone. The region, in great part, pertains to the occiput, with the curves of which it is continuous. Laterally, the mastoid region presents a large nipple-shaped process, the *mastoid process*, for the origin of the Sterno-Cleido-Mastoid and the Splenius Capitis muscles. In the majority of skulls an irregular depression is seen extending along the outer surface of the process. This marks the position of the primordial squamoso-petrosal suture. Behind the mastoid process lies *the digastric fossa*, for the origin of the Digastric muscle. Extending parallel with its outer side is *the groove for the occipital artery*. Above the mastoid process lies *the mastoid foramen* for the transmittal of a vein inwards to join the lateral sinus.

Medianly the mastoid division lies behind the petrous portion, and is marked with a deep broad sulcus for the lateral sinus. The union of the squamoso-parietal and masto-parietal borders exhibits a well-marked retiring angle for the posterior inferior angle of the parietal bone.

Development.—The temporal bone arises both from membrane and from cartilage: the squamous and tympanic portions from the former; the petrous portion and styloid process from the latter. Ossification is first announced in the squama as early as the third month. Shortly after this the process begins in the tympanic portion. Some obscurity exists respecting the development of the petrous portion, which usually is stated to arise at about the fifth or the sixth month from a number of minute granules; but from what is seen in lower animals there appear to be three separate ossicles in the bony envelope to the labyrinth. It is probable that in man more than three definite centres exist, but that they early coalesce. At birth the temporal bone is nearly complete, the several portions having united, but the mastoid process has not appeared, the styloid is yet cartilaginous, and the auditory meatus is shallow, since the tympanic portion is as yet a mere rim of bone.

Remarks.—The temporal bone is the seat of many pathological conditions, to appreciate which an exact knowledge of anatomy is required. M. Chassaignac[1] describes a case in which the right condyle of the lower jaw was driven into the skull by a fall from a great height upon the chin. The right condyle was found in the autopsy pressing against the middle lobe of the brain, in which was a large abscess.—Fracture of the vaginal process may ensue upon the lower jaw being driven directly backward.—But by far the greatest importance is to be attached to the complications arising from aural disease. Mr. Toynbee[2] has said: "Each of the cavities of the ear has its particular division of the encephalon to which it com-

[1] Plaies de Tété, 158.

[2] Med.-Chir. Trans., xxiv.

municates disease." A secondary inflammation may extend from the roof of the tympanic cavity to the cerebrum; from the external meatus and mastoid cells to the lateral sinus and cerebellum; and from the labyrinth to the medulla and the base of the brain. Of these the second is the most frequently seen. The mastoid cells lie in such close juxtaposition to the lateral sinus, that between the ages of eighteen and forty-five the septum is thin, and may in parts be absent, so that the lateral sinus touches directly the mucous lining of the cells. In such cases, an inflammatory process may extend from the mastoid cells to the lateral sinus, and encranial phlebitis and death may ensue. As a rule, however, inspissation of the mucus of the mastoid cells, if not suppuration and caries, precedes the meningeal complication.—The mastoid foramen has been known to discharge pus from a deep-seated abscess, as seen in the interesting case reported by Dr. F. Buszard.[1] The patient had suffered eleven months. During the latter portion of this term drowsiness and vomiting were noticeable symptoms. The bone was trephined over the position of the foramen, when the escape of viscid pus, which was believed to have formed within the cranium, followed. The patient recovered.—The petrous, the squamous, and even the tympanic portions of the temporal bone are occasionally lost by necrosis. Mr. Hinton[2] reports an instance of the exfoliation of the right tympanic bone in the course of an attack of ostitis following scarlatina in a child five years old.

P. Hewitt[3] reports a remarkable instance in which the entire bone died and was removed, with a fatal result. The case was that of a boy eleven years of age, the subject of chronic ear discharge. At the autopsy the auditory and facial nerves were seen to terminate in a bulbous mass on the dura mater. The internal carotid artery above and below could be traced as far as the walls of the cavity which had lodged the bone. The vessel was reduced to a small size, however, before it reached this spot, and was impervious.

While the temporal bone is not very vascular, as the frequency and extraordinary extent of necrosis above mentioned would indicate, severe and even fatal hemorrhage has attended the removal of bony sequestra (see account of Common Carotid Artery). Meningitis and inflammation of veins joining the lateral sinuses may also succeed necrosis of this bone.

[1] Brit. Med. Journ., 1871, 88.
[2] Trans. Path. Soc., London, 1866, 274.
[3] Med. Times and Gazette, 1864, i. 205.

The mastoid process, according to Portal,[1] is at times the seat of large syphilitic exostoses.

The space behind the ear in the living subject is sometimes called the *mastoid fossa* in clinical reports. It, however, lies for the most part above the mastoid process, and answers to the squamous surface. The term *post-auricular space* is here more appropriate. This space, together with the squama, and the portions defining the external meatus, are the only parts of the temporal bone that can be detected in the undissected subject.

THE SPHENOID BONE.

The sphenoid bone (figs. 1 and 2, Plate XVII., Plate XXIV.) occupies a central position in the head. Before it lies the face; behind it the temporal bone and the basilar process of the occipital. At the sides it joins the parietal and frontal bones, as well as the squamous portion of the temporal bone. It enters into the construction of the roof of the pharynx and nasal chambers, affords attachment to three of the four masticatory muscles, supports the superior dental arch posteriorly, forms part of the outer wall of the orbit, and the anterior and middle cerebral fossæ. It is perforated by foramina for branches of the fifth pair of nerves, the optic nerve, and the meningeal arteries.

The sphenoid bone is divided into a *body* and *three pairs of processes*, named as follows: the *lesser wings*, projecting outward from the side of the body anteriorly; the *greater wings*, from the side of the body posteriorly; and the *pterygoid processes*, projecting downward from the sides of the body beneath.

The *body* of the bone is of a quadrilateral figure, and presents for examination six surfaces, the *superior*, *inferior*, *anterior*, *posterior*, and two *lateral* surfaces.—The *superior* surface lies entirely within the brain-case. It is marked in front by the *ethmoid spine;* behind this by a smooth surface which is but faintly marked by a median elevation continuous with the crista galli of the ethmoid bone. On either side lies *a groove for the olfactory tract.* Connecting these grooves is a nearly transverse sulcus—*the optic groove*—to accommodate the optic nerves. Directly behind this groove is the *olivary process* for the support of the *optic chiasm.* The remainder of the surface is deeply concave, and forms the *pituitary fossa* (sella turcica) for the reception of the pituitary body. Limiting this fossa posteriorly is an oblique plate of bone, directed downward and backward, called the *dorsum sellæ* (clivus). When the sphenoid bone is in articu-

[1] Anat. Medical.

lation with the occipital, the dorsum sellæ is seen to be continuous with the upper surface of the basilar process, and aids in supporting the pons Varolii. The dorsum sellæ is composed of loose spongy tissue, and ends anteriorly by a free border, the outer angles of which are called the *posterior clinoid processes.*—The *inferior* surface is continuous with the anterior, presenting in relation to it no well-defined boundary. Conspicuous upon the surface is a triangular spine—the *rostrum*—which in articulation with the vomer fits into its upper groove. On each side is a narrow depression, covered in part by a transverse lamina—*the vaginal process*—derived apparently from the base of the pterygoid process to articulate with the alæ of the vomer.—The *anterior (nasal) surface* presents a continuation of the rostrum which here articulates with the perpendicular plate of the ethmoid bone. On each side of this median projection lies a *sphenoidal turbinated bone.* Each sphenoidal turbinated bone is defective in its upper part. It is of a triangular figure, its apex pointing downward and backward. It is a distinct bone in the infant, but soon unites with the ethmoid bone in front and the sphenoid behind. With its fellow of the opposite side it largely contributes to the formation of the sphenoidal sinus. Inferiorly the parts on each side of the rostrum are in part concealed by the apices of the sphenoidal-turbinates.—The *posterior surface* is of a quadrangular figure, which in the young subject is covered with cartilage. It articulates with the basilar process of the occipital bone. At the sides a minute process is seen which aids in forming the groove for the superior petrosal sinus.—The *lateral surfaces* of the body are almost entirely within the braincase, a small portion only extending forward to terminate at the corresponding surfaces of the sphenoidal turbinates. Each surface presents a conspicuous depression for the internal carotid artery (*sigmoid groove*). It is better defined posteriorly than anteriorly, and along its lateral than median border. Two minute processes are detected along the course of the groove; the first and larger at the lateral border of the beginning of the groove called *the sphenoidal tongue*, and the second at the median border of the anterior end, called *the middle clinoid process.*—The *body* of the bone thus defined is hollow in the adult to form *the sphenoidal sinus.* This sinus is so often divided by a vertical septum into two that the term *sphenoidal sinuses* would be more appropriate. Clinical writers, however, invariably speak of it as a single chamber. The sphenoidal sinus communicates with the posterior ethmoidal cells, but commonly opens upon the nasal fossæ.

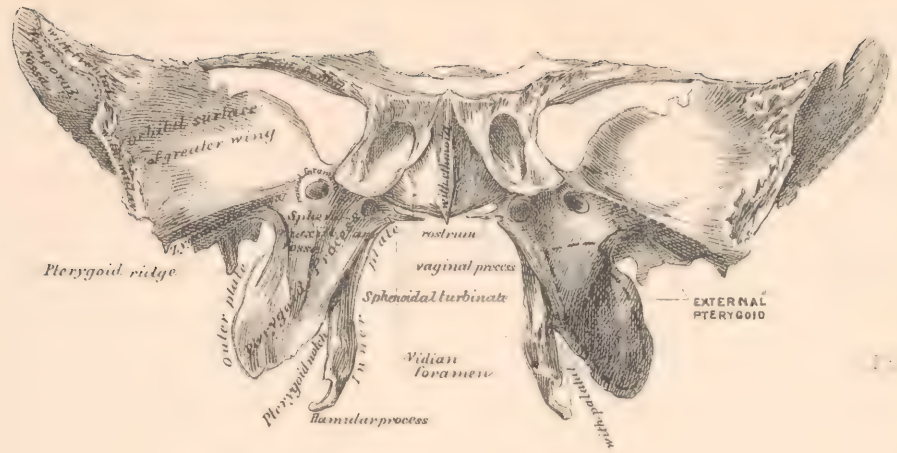
The *greater wing* of the sphenoid bone springs from the base and the hinder portion of the lateral surface. It consists almost entirely of spongy tissue. It arises by a massive base at the inferior border of the body of the bone, slightly in advance of the beginning of the carotid groove and behind the sphenoidal fissure. It is divided conveniently into a horizontal and an ascending portion.—The *horizontal portion* is smaller than the ascending. Its upper surface is marked at its outer half by a thick oblique irregular surface for articulation with the squamous portion of the temporal bone. The posterior border presents a compressed thin edge, which is slightly concave below, and forms when the bone is articulated a sulcus for the cartilaginous portion of the Eustachian tube. The under surface is smooth, and bounded externally by the *zygomatic crest.* Posteriorly the under surface terminates in a sharp process, directed downwards, termed the *spinous process.* To it is attached the internal lateral ligament of the lower jaw.—The *ascending portion* passes outward and slightly forward, and upward, to be received anteriorly by the frontal bone through a broad triangular, irregular surface at the outer side of its orbital plate, and the anterior inferior angle of the parietal bone. Posteriorly it is received by the squamous portion of the temporal bone. It is concave within to receive the middle lobe of the cerebrum. It is slightly concave without, where it is marked by two muscular impressions, one above the *pterygoid ridge* for the Temporal muscle, and the other below the ridge for the origin of the outer head of the External Pterygoid muscle. The process is smooth in front to form the *orbital surface*, and enters into the outer wall of the orbit. The orbital surface is of a quadrangular figure. It is notched at its inner surface for the passage of a branch of the ophthalmic artery. It is compact where it bounds the sphenoidal tissues inferiorly; made up of spongy tissue in the centre, it is again thin and compact

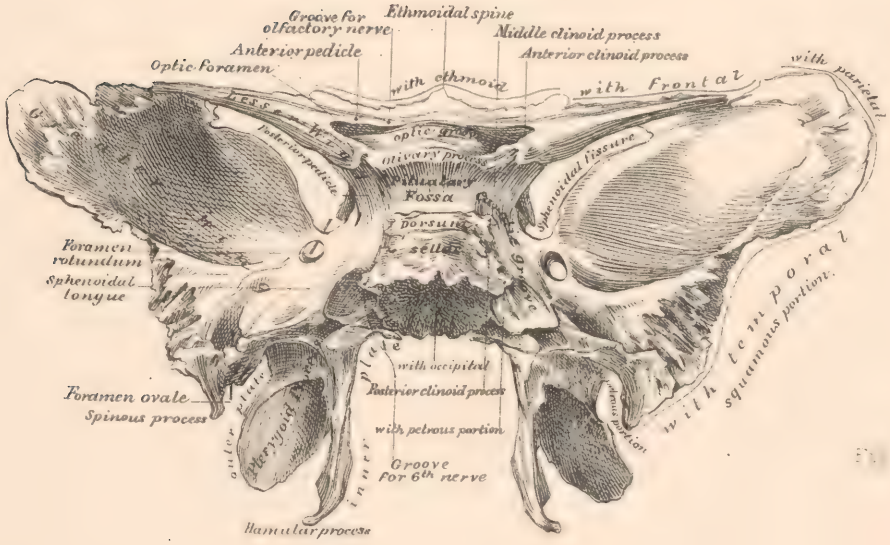
EXPLANATION OF PLATE XVII.

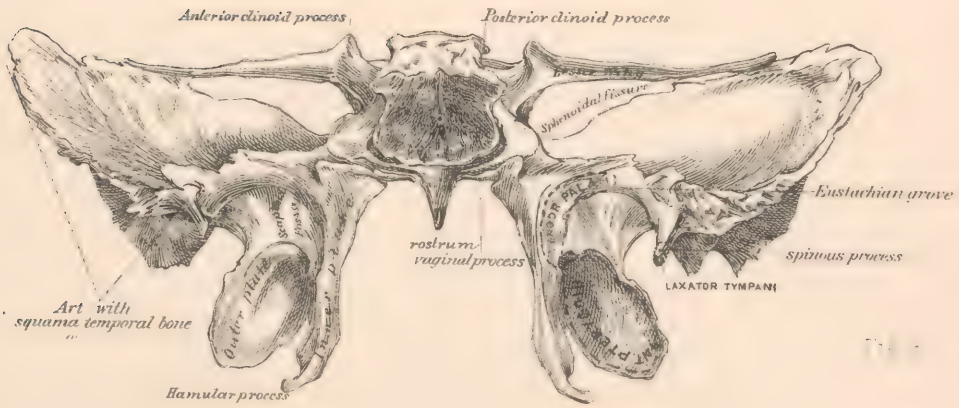
Fig. 1. The sphenoid bone seen from in front.

Fig. 2. The sphenoid bone seen obliquely from above.

Fig. 3. The sphenoid bone seen from behind.







T. Sinclair & Son, sc.

where it joins the malar bone to form the sphenotemporal partition. Between the pterygoid impression and the orbital plate a well-defined groove is seen leading to the spheno-maxillary surface.

The *lesser* wing, composed of compact tissue, arises from the junction of the side with the upper surfaces of the sphenoid bone. It passes horizontally outward, and tapers as it approaches the greater wing to which at the fronto-sphenoid junction it may be attached. It possesses two pedicles. The *anterior* is thin, and lies on the same plane with the orbital part of the frontal bone. The *posterior* is stout and rounded, and is continuous with the outer edge of the olivary process medianly, and with the under thickened free border of the lesser wing laterally. The anterior border of the lesser wing is thin and serrate to articulate with the frontal bone. The posterior border is thickened and free. Its median extremity projects inward to form *the anterior clinoid process.* This process presents a median border grooved for the ophthalmic artery, and a shelving external border which overhangs the sphenoidal fissure. The opening between the anterior and posterior pedicles is the *optic foramen*, which transmits the optic nerve and the ophthalmic artery. The posterior pedicle separates the optic foramen from the sphenoidal fissure. The anterior surface of the lesser wing as it lies behind the cribriform plate of its own side sends forward a small process of bone, which aids in covering in the posterior ethmoidal cells.[1]

The *pterygoid processes* of each side descend from the junction of the body with the greater wing. Anteriorly the process forms at its upper third a smooth triangular surface, which forms the posterior wall of the spheno-maxillary fossa. The remaining portion of the process is in articulation with the palatal bone. Posteriorly the process is free along its entire border.—The pterygoid process is in great part divided into an *inner* and *outer* plate. The space between these plates, best seen from in front, is called the *pterygoid notch*, which is occupied in the skull by the pyramidal process of the palatal bone. The space between the plates seen from behind is called the *pterygoid fossa*, and gives origin to the Internal Pterygoid muscle. The *outer* pterygoid plate is broader than the inner, and is directly continuous with the outer wing. It is deflected slightly outward and forward to articulate with the palatal bone above the dental alveoli. The lower head of the External Pterygoid muscle arises from its outer surface. The *inner* plate is a compressed vertical layer of bone articulating in front with the palatal bone. The inner plate is free behind. Its inferior portion is prolonged as a hook-like extension, forming the *hamular process*, over which plays the tendon of the Tensor Palati muscle. The pterygoid fossa as it terminates superiorly is continuous with a small elliptical depression, which has received the name of the *scaphoid fossa.* It gives origin to the Tensor Palati muscle.

The Foramina of the Sphenoid Bone.—The foramina of the great wing are as follows: First, the *round foramen*, seen at the anterior third of the side of the body and directed forward. It transmits the superior maxillary branch of the fifth pair of nerves. Second, the *oval foramen.* This is a large opening in the horizontal portion of the greater wing near its petrosal border, behind and to the outer side of the round foramen. It is directed downward, and transmits from above the inferior maxillary branch of the fifth pair, and from below the lesser meningeal artery. Third, the *spinous foramen*, which transmits the great meningeal artery. The pterygoid process exhibits a canal at its base directed horizontally forward, which, transmitting as it does the great petrosal or Vidian nerve, has received the name of the *Vidian canal.* The internal pterygoid plate is marked at its base internally by a minute opening which, when the bone is articulated with the palatal, is converted into a canal known as the *pterygo-palatine canal* for the artery and nerve of the same name.

The space between the greater and lesser wings is of an irregular form, broader at the body of the bone than at the outer end, where it is narrowed to a mere chink. This space in the separate bone has received the name of the *sphenoidal fissure*, and in the skull the *anterior lacerated foramen.* It transmits the third, fourth, and sixth nerves, the ophthalmic branch of the fifth nerve, and the ophthalmic vein.

STRUCTURE.—The structure of the sphenoid bone, as already mentioned, is for the most part spongy. The greater wing with the exception of the horizontal plate is composed of thick vascular spongy tissue. In skulls that have been much weathered this tissue becomes exposed, and may be eroded to a great extent. The pterygoid process at its base, and including in great part the inner plate, is also spongy. The lesser wings are compact.

DEVELOPMENT.—The sphenoid bone develops from thirteen to fifteen centres of ossification, viz., one for each greater wing, inclusive of the external pterygoid

[1] For special description of this process in man and fox, see Luschka, Zeit. für Wissenschaft. Zool. viii., 1857, 123, Taf. iii.

process; two for the posterior portion of the body, or the basi-sphenoid; one for the anterior portion of the body, or the pre-sphenoid (this is occasionally absent); one for each of the lesser wings (these extend into and occupy the cartilage of the pre-sphenoid in the event of no separate centre arising therein); one for each of the internal pterygoid plates; one for each of the sphenoidal turbinate (three separate ossicles may be detected here); and one for each of the sphenoidal tongues.

The order in which these several centres appear is as follows: The centre for the greater wings, which appears at about the second month; the centres for the basi-sphenoid, nearly the same time; the centre for the pre-sphenoid, at about the ninth week, including those for the lesser wings; the centres for the internal pterygoid plates and the sphenoidal tongues, at the fourth month; the centres for the sphenoidal turbinates, at about puberty.

At birth the sphenoid bone is composed of three pieces—the two greater wings with the internal pterygoid plates, and the two lesser wings with the body. The greater wings join the body at the end of the first year. The sutural line of union between the pre-sphenoid and basi-sphenoid is seen as late as the third or fourth year; the turbinates join the pre-sphenoid, and the basi-sphenoid joins the occipital at puberty.

Remarks.—The greater wing of the sphenoid bone is often the seat of inflammation in strumous and syphilitic subjects. In most specimens of the sphenoid bone of the adult this portion is seen conspicuously marked with vascular foramina. The region of the pituitary fossa is occasionally the point of origin of diseased action—either within the body of the bone or within the pituitary body—which may extend laterally and involve the cavernous sinuses,[1] and the internal carotid arteries. Instances have been recorded of caries of the body eroding one of the last-named vessels and causing fatal hemorrhage.

[1] W. Moxon. Tr. Clin. Soc. Lond., v. 45.

Robert[1] mentions an instance of fracture of the body of the sphenoid bone at the sella turcica, the dura mater in contact with it being torn. The crevice thus formed had communicated directly with the roof of the pharynx during life, and the sub-arachnoid fluid had trickled through the opening into the nose, creating a watery discharge.

For additional remarks see Base of Skull.

THE PARIETAL BONE.

The parietal bone (Plate XVIII.) is of a quadrilateral figure, and is situated on the side of the cranial vault between the fellow of the opposite side, the squamous and the mastoid portions of the temporal and the great wing of the sphenoid bone below, the frontal bone in front, and the occipital bone behind.

The *anterior superior angle* is a right angle. It is developed in infancy to aid in closing the great fontanelle. The *postero-superior angle* is an obtuse angle, and assists in closing the postero-superior fontanelle. The *antero-inferior angle* is in the isolated bone the most produced of any. It forms a narrowed tongue of bone fitting in the space between the frontal and temporal bones, and articulates with the sphenoid bone. The *postero-inferior angle* is broader and more truncated than the others. It joins the mastoid portion of the temporal bone.

The parietal bone is composed of one or more layers of spongy tissue, placed between two plates of compact tissue, of which the outer is the most variable. The bone presents for examination two surfaces and four borders and angles. The bone is marked externally by a conspicuous rounded elevation, termed the parietal eminence—which corresponds to the centre of ossification. At the lower part of the external surface is seen a semicircular canal, limiting the temporal fossa superiorly. The bone is concave, and is deeply grooved by the great meningeal artery, which is directed from below upward and before backward from the antero-inferior angle. Near the upper margin of the bone

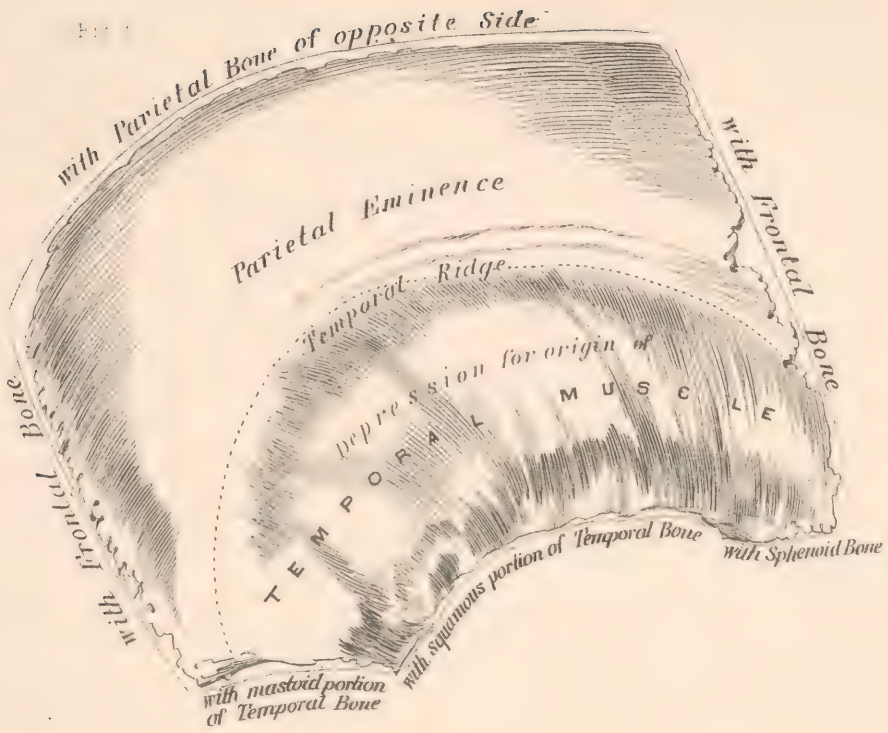
[1] Gazette des Hôpiteaux, 1840, 205.

EXPLANATION OF PLATE XVIII.

Fig. 1. The parietal bone seen from without.

For the words "with frontal bone" on left hand border read "with occipital bone."

Fig. 2. The parietal bone seen from within.





T Sinclair & Son Lith.

are seen several shallow depressions for the Pacchionian bodies. Inferiorly and posteriorly the inner surface is grooved for the transverse sinus. The *upper*, *anterior*, and *posterior* borders are simple in character, and present coarse serrations for articulation with adjacent bones. The *inferior* border is bevelled at its anterior two-thirds for articulation with the squama —the posterior third being coarsely serrated, to articulate with the mastoid division of the temporal.

Development.—The parietal bone arises from a membranous matrix by a single centre of ossification which appears at the seventh or eighth week.

Remarks.—This bone will occasionally exhibit between the parietal eminence and the borders of the bone one or more foramina of large size. They are evidences of defective development of the part, which process would appear to be less active in the region between the centre of ossification and the borders of the bone than elsewhere. Dr. J. S. Parry[1] has associated the tendency to such a condition with rickets. Prof. Turner[2] believes these openings to be enlarged vascular foramina, for although they are occupied with membrane during life, such membrane was found by him to be perforated by minute vessels.

THE FRONTAL BONE.

The frontal bone (figs. 1, 2, and 3, Plate XIX.) is a symmetrical bone situated at the anterior part of the cranium between the parietals above, the wings of the sphenoid behind, and the bones of the face below.

It is for the most part composed of compact tissue. The bone supports the anterior half of the cerebrum within; it affords attachment to the part of the Temporal muscle at its sides, where it enters into the composition of the temporal fossa. It forms the roofs of the orbits, and receives the cribriform plate of the ethmoid bone.

The frontal bone is divided into an ascending and a horizontal portion. The *ascending portion* is marked anteriorly by the upper margins of the orbits—the *supra-orbital arches*. At the inner third of each arch is seen the *supra-orbital notch*, for the escape of the frontal branch of the ophthalmic nerve. This is sometimes converted into a foramen. The outer extremity of the arch is continuous with the external angular process; the inner extremity—more produced —forms the *internal angular process*. Between the two internal processes lies a rounded elevation—the *nasal eminence*, which forms the anterior wall of the frontal sinus.

The *frontal sinus* (fig. 1, Plate XXIII., figs. 1 and 2, Plate XXIV.) is an irregular chamber, lined with mucous membrane, situated between the inner and outer plates, at the junction of the ascending and horizontal portions. It communicates with the nasal chamber by means of the infundibulum of the ethmoid bone. The inferior surface is irregularly serrate for articulation with the ascending process of the superior maxillæ, the nasal bones, and the vertical plate of the ethmoid. A conspicuous median process of the frontal bone—the *nasal spine*—is firmly wedged between these bones. Extending from the base of the process upward along the median line are seen the remains of the frontal suture. Upon either side of the frontal suture is the circular *frontal eminence*, and below each eminence the *supra-ciliary ridge*, which corresponds pretty nearly with the supra-orbital arch of its own side. Laterally the ascending portion is marked by a muscular impression, called the *temporal ridge*, which limits the anterior third or fourth of the temporal fossa. Between this ridge and the supra-orbital arch is produced the external angular process, a conspicuous mass of spongy tissue articulating with the malar bone and the greater wing of the sphenoid bone. The *posterior*, or encranial surface, is smooth for the reception of the anterior lobes of the cerebrum. In the middle line is seen a deep narrow sulcus, narrower below than above, for the great longitudinal sinus. Inferiorly in front of the ethmoidal notch the sulcus ends in a minute opening, the so-called *foramen cæcum*. This opening is continuous in childhood with the nasal chambers, and transmits a small vein. In the adult it is closed, and is occupied by fibrous tissue.

The *horizontal portion* is composed of the two *orbital plates* and the *ethmoidal notch*. The *orbital plates* are two thin laminæ, which, as already said, form the roofs of the orbits without and the floor of the anterior cerebral fossa in the main within. The orbital surface is smooth save at the anterior portion of the median half, where it is marked by a minute process for the tendon of the Superior Oblique muscle. Behind the external angular process the orbital plate accommodates the lachrymal gland. The encranial surface is more uneven than the orbital, and slopes gently toward the ethmoidal notch. Each plate is marked by two or three irregular elevations forming several shallow depressions, which, from the fancied resemblance they are thought to bear to the impressions

[1] Amer. Journ. Med. Sci., Jan. 1872, 43.

[2] Edinburgh Royal Soc. Proc., v. 1877, 444.

made by finger-tips upon some yielding substance, have received the name of the *digital depressions*.

The *ethmoidal notch* is designed for the reception of the cribriform plate of the ethmoid bone. Its sides exhibit numerous irregular cell-like depressions, which assist when the bone is in articulation to form the ethmoidal cells.

Development.—The frontal bone arises from membrane by two centres of development, one on either side of the median line. These centres appear near the orbital arches at the seventh week. The bone is composed of two pieces at birth. The suture between the right and left halves is called the *frontal suture*, and is in the line of the interparietal or sagittal suture. It is commonly obliterated at about the third year. The occasional persistence of this serrate suture is a subject of more than passing interest. Surgeons have been known to confound such a suture with a line of fracture.[1]—Authorities vary with respect to the time of development of the frontal sinus. Albinus described the sinus as existing in the fœtus of nine months. Blumenbach[2] and Henle believe it to be formed at the end of the second year. Its development would appear to be variable, and to be retarded by some diseases, among which may be mentioned rickets, scrofula, and hydrocephalus.

Development of the bone may be varied by the appearance of accessory centres upon the orbital plates. These frequently remain separate from the rest of the bone, resembling in their independent position the Wormian bones. Joh. Czermak[3] has described six cases of such abnormally constituted orbital plates.

Remarks.—From want of proper union of the halves of the frontal bone hernia cerebri has been known to occur at the frontal suture.—Mr. Shaw exhibited before the Pathological Society of London an encephalocele removed from the head of an infant. The mass had projected through an opening in the frontal bone at the root of the nose, between the sutures uniting the frontal, ethmoid, and nasal bones.[1] —The frontal bone will yield occasionally small exostoses. These are sometimes of extraordinary compactness, and involve the median portion, as well as the orbital plates.—The frontal bone is infrequently fractured where it is most convex, as at the frontal and nasal eminences. It is relatively often fractured at the sides where the bone enters into the composition of the temporal fossæ, notwithstanding that in such locality the bone is protected by the Temporal muscle and aponeurosis.—The external angular process of the frontal bone frequently presents upon its orbital aspect, and thence to the roof of the orbit, a patch of foramina. In the same locality a cribriform exostosis has been occasionally observed.

The outer (anterior) wall of the frontal sinus has been removed for the extraction of polypi growing from the mucous membrane lining the sinus.[2] In a case mentioned by Jno. Bell,[3] the polypous tumors pressed the inner wall of each orbit outward, while the posterior wall was pressed backward.

Owing to the continuity of the frontal sinus with the nasal chamber larvæ of insects can readily pass from the latter to the former. Numerous cases of this condition have been observed, chiefly in tropical countries.

The size of the frontal sinus is subject to great variation. Usually confined to the frontal eminence or the space continuous thence with the supraorbital arches, it may extend over the entire length of supraorbital arches. It is apt to increase in size with advancing years. Under the influence of diseased action the frontal sinus may be obliterated, as in syphilis. One half of the sinus is apt to be larger than the other. Richet candidly mentions an expe-

[1] Velpeau, Anat. Chirurg., 228.
[2] History and Diseases of Bones, etc., Göttingen, 1786, 101.
[3] Zeitschr. für Wissenschaft. Zool., iii. 27, pl. 2.

[1] Trans. Path. Soc. of Lond., 1858, 2.
[2] Lancet, 1859, ii. p. 634.
[3] Principles of Surgery, iii. p. 134.

EXPLANATION OF PLATE XIX.

Fig. 1. The frontal bone seen from the side.
Fig. 2. The frontal bone seen from beneath.

A leader should be drawn from the words "with Sup. Maxilla" to the surface directly behind the one for articulation with the nasal bones.

Fig. 3. The frontal bone seen from in front.
Fig. 4. The ethmoid bone seen from beneath.

For "Unciform Process" read "Uncinate Process."

Fig. 1

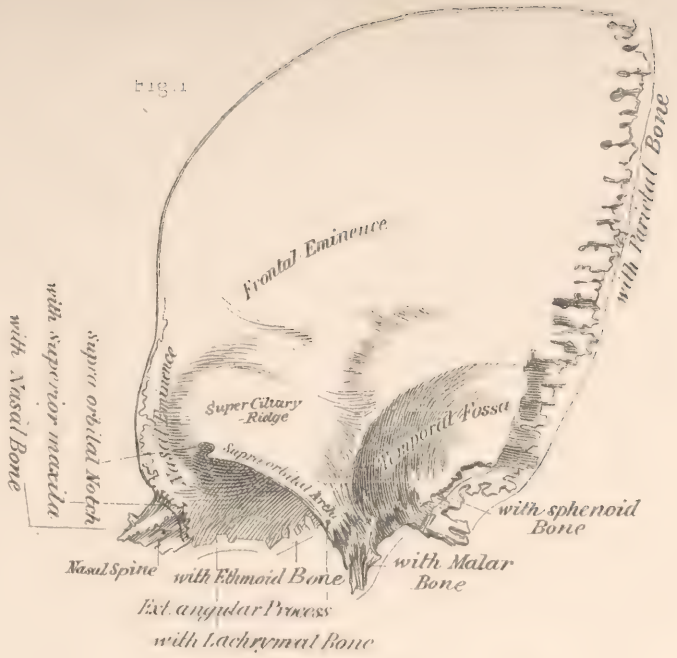
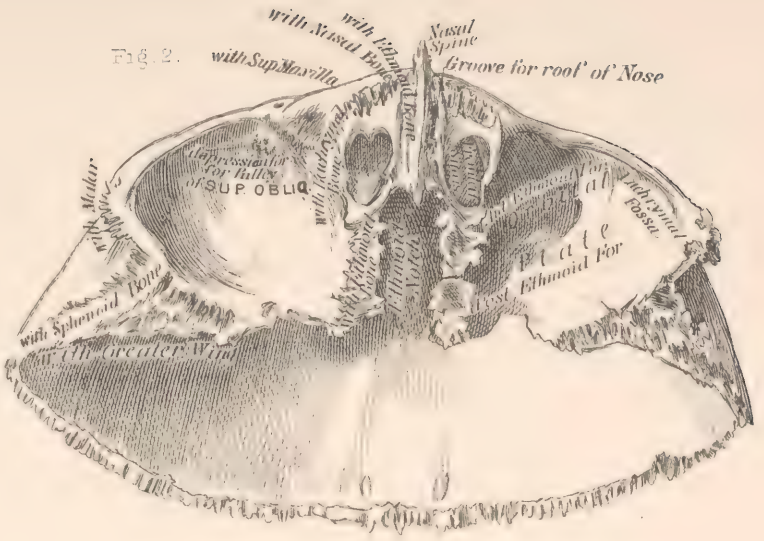


Fig. 2.





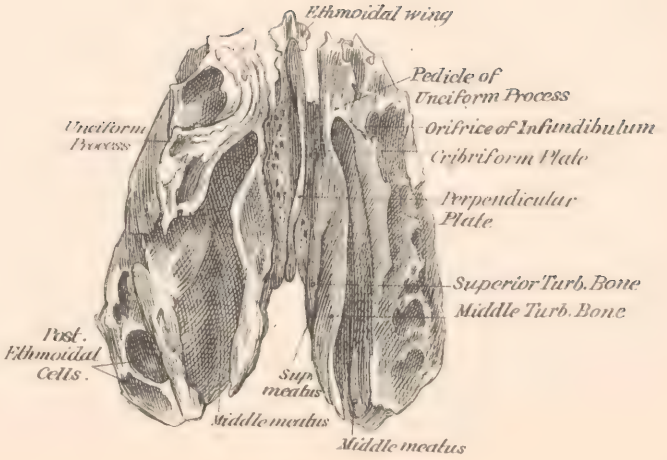


PLATE XIX

rience of his own in which he for a time mistook such an asymmetrical growth for an exostosis.

From the extreme thinness of the orbital plates a slight direct blow will break them. This has actually occurred in more than one instance. Inconsiderable and sometimes undetected external wounds, from such objects as tobacco-pipe stems, and tips of umbrella sticks, have been associated with fracture of the orbital plate and cerebral injury.[1]

Abscess of the frontal sinus will expand the walls and cause outward inclination of the inner aspect of the orbit above the os planum of the ethmoid. A patient under the care of Mr. Soelberg Wells,[2] showing these peculiarities, had, in consequence of periocular infiltration as well as from the direct pressure of the abscess, protrusion of the right eyeball.

THE ETHMOID BONE.

The ethmoid bone (fig. 4, Plate XIX.; fig. 1, Plate XX.)—while properly a cranial bone, inasmuch as it enters into the construction of the brain-case—lies for the most part within the region of the face. Like the sphenoid bone, it is strictly symmetrical; and is composed of a median portion which receives the name of the *vertical plate*, and two *lateral portions* or *masses*. Uniting the vertical plate and the lateral masses is the *horizontal* or *cribriform* plate. The entire bone is of a cuboidal figure, and aids in defining the floor of the anterior cerebral fossa, the nasal chambers, and the inner wall of each orbit. The nasal surfaces of the ethmoid are covered with mucous membrane that accommodates the organ of smelling.

The *vertical plate* (meso-ethmoid) is a thin lamina of bone in the median line extending downward from the cribriform plate into the face, and upward from the cribriform plate into the brain-case. The downward extension is vastly the larger of the two, and has received the name of the *perpendicular plate* of the ethmoid bone. It constitutes the upper third of the nasal septum. Its anterior boundary is inclined forward, and articulates with the nasal spine of the frontal and the crest of the nasal bones. The posterior border joins the sphenoidal crest of the sphenoid bone. The inferior border is obscurely angulated: the portion sloping upward and forward in front of the angle articulates with the triangular cartilage of the nose, while the portion back of the angle articulates with the vomer. The sides of the vertical plate are grooved for the olfactory nerves.

[1] Dublin Journ. of Med. Sci., xi. p. 353.

[2] Lancet, 1870, p. 694.

The upward extension of the vertical plate forms a robust angulated ridge, ivory-like in appearance, which has been named, from its assumed resemblance to the cock's comb, the *crista galli*. Seen from the cranial surface, the *crista galli* appears to arise from the horizontal plate. Its anterior border is nearly vertical, and is provided at its base with two symmetrical flanges—the so-called *ethmoidal wings* or *alæ*. The great longitudinal fold of the dura mater is attached to the crista galli.

Each *lateral mass* (ethmo-turbinate bone) is of a cuboidal figure, and presents, therefore, six surfaces for examination. Of these, the *superior* and *inferior* are imperfectly defined; the former being composed of irregular cellules that are covered in and completed by the frontal bone; the latter, being part of the complicated median surface, can be described in connection therewith.

The *median* or *nasal* surface (fig. 2, Plate XXIV.) is of great complexity. It is defined by a lamella that arises from the cribriform plate and descends at its anterior third to the inferior border without interruption. At its origin anteriorly it is continuous with the pedicle of the uncinate process, and posteriorly with the spheno-turbinated bones. At its posterior two-thirds, the nasal surface is interrupted by a large horizontal sulcus, called, from its relations to the topography of the nasal chamber, the *superior meatus*. It is continuous with the posterior border of the bone which it deeply notches. All that portion of the bone lying between the cribriform plate and the upper margin of the sulcus is called the *superior turbinated bone*, and all that portion between the lower border of the sulcus and the lower margin of the nasal surface is called the *middle turbinated bone*. The middle turbinated bone is scrolled outward, and constitutes the most conspicuous feature on the *under* surface of the bone. Directly to the outer side of the middle turbinate lies the large sulcus, known, when the ethmoid is articulated with its associate bones, as the *middle meatus*. The entire median surface of the ethmoid is minutely roughened and pitted by the delicate canals and openings of exit of the olfactory nerves.

Arising in common with the anterior margin of the median surface, to which it may be regarded as an appendage, is the *uncinate process* or *process of Blumenbach*. This is an irregular lamina extending downward, outward, and backward—lying at first to the median side of the ascending process of the superior maxilla, and then to the median side of the lachrymal. The uncinate process articulates with the ethmoidal process of the inferior turbinated bone,

and aids in closing the orifice of the maxillary sinus.

The *lateral* or *outer* surface of the lateral mass is nearly smooth. Its anterior portion is cellular, and is covered in by the lachrymal; the remaining portion forms the median wall of the orbit, and, from its uniformly smooth appearance, has received the name of the *os planum* (fig. 1, Plate XXIV.). Two grooves at the upper margin of the os planum transmit ethmoidal branches of the ophthalmic nerve. The thin *posterior* surface joins the sphenoid.—The space between the median and lateral surfaces of the lateral mass is occupied by the superior meatus and a number of open spaces lined with mucous membrane which have received the name of the *ethmoid cells*. Two sets of these cells are described, viz., the anterior and the posterior. The posterior set of cells opens upon the superior meatus, while the anterior cells are continuous with the frontal sinus by means of a passage known as the *infundibulum*. Inferiorly, the anterior cells communicate with the middle meatus.

The *cribriform plate* or *lamella* (fig. 1, Plate XXIII.) unites the cranial surfaces of the lateral masses and the vertical plate. Strictly speaking, there are two cribriform plates, one on each side of the *crista galli*. Each plate receives the olfactory bulb of its own side —hence it is sometimes called the *olfactory sulcus*— and transmits the olfactory nerves arising from its under surface. The numerous openings of the cribriform plate are arranged without apparent order. They are for the most part the orifices of obliquely-placed short canals. Directly behind the ethmoidal wing lies a narrow slit-like opening for the nasal branch of the ophthalmic nerve.

Structure.—The ethmoid bone is composed of delicate lamellæ of varying degrees of thickness. The thickest portions of the bone are the crista galli —which is occasionally hollow—the wings, and the pedicle of the uncinate process.

Articulation.—The ethmoid bone articulates by the perpendicular plate with the vomer; the lateral masses with the frontal, sphenoid, nasal, lachrymal, superior maxillary, and palatal bones, and by the uncinate process with the inferior turbinated bone.

Development.—The ethmoid bone arises from three centres of ossification, one for each lateral mass, and one for the vertical plate. The orbital plates begin to ossify in the fourth or fifth month; the vertical plate and the cribriform plate within the first year. The bone is complete at the fourth or fifth year.

Remarks.—For detailed clinical application of the anatomy of the ethmoid bone, see Nose. The cribriform plate can be readily fractured by instruments thrust upward from within the nasal chamber, and the brain thus penetrated. After such a method infanticide has been committed. It is asserted that the ancient Egyptians removed the brains of their dead through such an opening prior to subjecting the bodies to the embalming process. A case has been reported[1] having for conspicuous features a fracture of the cribriform plate, a punctured wound of the brain, and a foreign body, in the shape of the ferule of a fencing cane, lying at the side of the clinoid processes of the sphenoid bone. While engaged in a friendly exercise at fencing, the patient had received a thrust from his opponent, which had entered the nose and passed with but little opposition through the cribriform plate to the middle of the base of the skull (compare fig. 2, Plate XXIV.). Operation upon the nasal chambers, as, for example, the removal of a polypus by evulsion, has in more than one instance been followed by inflammation of the soft parts overlying the cribriform plates. When the olfactory nerve is absent, as in cyclops monsters, the olfactory foramina of the cribriform plates are absent also. Cerebral hernia has occurred through the cribriform plate into the nasal chamber.[2] Retzius refers to a case of simple congenital meningocele at the root of the nose in a woman aged twenty-five.

THE VOMER.

The vomer (fig. 2, Plate XX.) is a thin rhomboidal lamina of bone situated in advance of and beneath the body of the sphenoid and between the nasal chambers. It presents for examination an anterior, posterior, superior, and inferior border, and a right and a left surface. The *anterior* border is oblique from above downward and from behind forward to articulate with the perpendicular plate of the ethmoid bone and the triangular cartilage. The *posterior* border is shorter than the anterior, and is free. It serves to separate the posterior nares from each other. The *superior* border presents a V-shaped depression for articulation with the rostrum of the sphenoid bone, and is furnished with stout everted lips, termed the *wings of the vomer* (alæ). The lateral edge of each wing unites with a thin lamina from the internal pterygoid process of the sphenoid bone and the sphe-

[1] Dublin Journ. of Med. Sci., xi. 349.

[2] Velpeau, Chirurg. Anat., i. 104; Spring, Hernie du Cerveau, Brussels, 1855.

noidal process of the palatal bone. In carefully macerated specimens of the vomer a small ridge is seen, which limits the plane of the posterior nares superiorly. The *surfaces* of the vomer are smooth save where they are grooved for the naso-palatine vessels and nerves.

STRUCTURE.—The vomer is composed of two layers of bone, which slightly diverge at the anterior border. In fresh specimens there is found in the groove in this way formed a thin rod of cartilage, which is continuous with the triangular cartilage.

ARTICULATION.—The vomer articulates with the sphenoid, ethmoid, palatal bones, and the superior maxillæ, and with the triangular cartilage.

DEVELOPMENT.—The vomer arises from the perichondrium of the septal cartilage by a single centre of ossification.

REMARKS.—The vomer presents the following variations: The two layers composing the bone are very distinct—an evidence of unusual degree of persistence of the septal cartilage. The wings may be greatly exaggerated—recalling exostoses. The wings may be very small, and the groove between the plates anteriorly occupied by calcified cartilage.

THE SUPERIOR MAXILLA.

The superior maxilla (figs. 3 and 4, Plate XX.) occupies the space between the orbit and the mouth—the zygomatic fossa laterally, and the outer wall of the nose medianly. It assists in forming the floor of the orbit, the outer side and floor of the nose, and the anterior nares, and affords lodgment for the upper teeth.

It presents for examination a central portion or body, and the nasal, palatal, malar, and alveolar processes.

The boundaries of *the body* correspond pretty accurately to the shape of a large cavity—*the maxillary sinus*. The antero-posterior section of the body bisects the sinus at the position of the first molar tooth. The sinus is of a triangular figure. One side of the triangle forms the floor of the orbit; another, imperfect one, the nasal side; while between the nasal and the orbital borders lies the facial. In a horizontal section of the body the posterior border is seen to be convex and directed towards the zygomatic fossa, hence the name given it of *the zygomatic surface*. The size of the maxillary sinus is subject to great variation. It may extend into the malar bone. It is occasionally divided into compartments by incomplete vertical septa.

The *orbital* surface of the body is a nearly smooth plane, and is slightly oblique from within outward. Its inner edge articulates with the lachrymal bone and the os planum of the ethmoid. Its outer edge joins the malar bone at its anterior half, and forms the inner border of the spheno-maxillary fissure at its posterior half. The orbital surface is marked by a groove running from behind forward, which terminates in a canal near the front edge. This is the *infra-orbital groove and canal* for the transmission of the infra-orbital nerve and artery. The orbital surface may serve to cover in the nasal chamber above the middle meatus.

The *inner* or *nasal* surface is imperfect. It presents an upper and a lower plate, with a large irregular opening between them. When the bones of the face are in position, this opening is partially closed by the palatal bone, the ethmoidal process of the inferior turbinated, and the uncinate process of the ethmoid.

The *lateral* or *facial* surface is concave, and extends from the root of the malar process forwards to the median line at the anterior nasal aperture. Its junction with the orbital plate is marked by a thickened border—the *infra-orbital ridge*—which is continued a short distance upon the ascending process. Directly below the ridge lies the *infra-orbital foramen* for the nerve and artery of the same name. Extending from the infra-orbital foramen to the alveolar process, to the outer side of the eminence of the socket for the root of the canine tooth, is a depression known as the *canine fossa*. To the median side of the canine depression lies the *canine eminence*, answering in position to the root of the canine tooth. Above the incisor teeth is seen a smaller depression—the *myrtiform fossa*.

The *posterior* or *zygomatic* surface is convex. It extends from the base of the malar process to the nasal aspect of the bone, where it joins the vertical plate of the palatal bone. It is separated from the orbital surface of its own bone by a sharp line at the inner border of the spheno-maxillary fissure. The zygomatic surface presents a rounded eminence above the alveolus for the last molar tooth, termed the *tuberosity*. Above it a short distance lie the *posterior dental foramina* for the transmission of the posterior dental artery and nerves. This surface presents medianly an articular surface for the pyramidal process of the palatal bone.

The *nasal process* is the stoutest in the region of the face. It is broader below than above, and is inclined upward and slightly backward to articulate

by a broad, jagged extremity with the frontal bone. The origin of the nasal process is best seen from within the nasal chamber; it here presents a smooth concave surface defined in front by the sharp compressed edge of the outer border of the anterior nasal aperture, and behind by the thickened anterior border of the lachrymal groove. This border is traceable upward to appear at the outer aspect of the bone on the inner wall of the orbit in front of the lachrymal bone, so that the lachrymal groove lies upon the inner side of the nasal process below and terminates at its outer side above. The nasal process is marked within by two *transverse ridges*, the lower for the inferior turbinated bone, the upper for the middle turbinated. The outer or facial surface may be divided at the level of the infra-orbital ridge into an upper and a lower portion. The upper portion is slightly concave externally, and marked by minute depressions thought to be traces of the development of the bone. Its anterior edge is articulated with the nasal bone. The infra-orbital ridge is here observed to be continuous with the anterior border of the lachrymal groove.

The *palatal process* is a horizontal plate of bone extending the entire length of the oral aspect of the superior maxilla. It is thinner at its middle than at either border. It is best defined opposite the second molar tooth, where it arises from the alveolar process and presents a thin transverse border for union with the palatal process of the palatal bone. It joins its fellow of the opposite side at the median line by a vertically serrate border; the upper edge of which, termed the *crest*, is produced to articulate with the vomer. The internal border of the palatal process is broader in front than behind, and it is continuous with the mesial border of the alveolar process at about the site of the *anterior palatine canal*. This foramen is best seen from beneath when the superior maxillæ are in position. It then presents an ovoidal depression, at the base of which is seen the median suture. Lying within this depression are the two minute *naso-palatine canals*. At its sides are seen the *incisorial foramina*. These two sets of canals transmit the terminal branches of the naso-palatine nerves from the nasal chambers to the roof of the mouth. The palatal process is smooth and concave above to enter into the floor of the nose, and roughened below for the attachment of the mucous membrane of the roof of the mouth. The lateral border of this surface is grooved for the posterior palatine artery and nerve.

The *alveolar process* extends along the under margins of the facial and zygomatic surfaces. It is a stout curved mass of spongy bone, placed at the sides of the hard palate and curved forward at the incisorial region to join its fellow of the opposite side at the median line. It is well defined within the cavity of the mouth, where it forms an angle with the palatal process. On the facial and zygomatic aspects it is continuous with the body of the bone. The alveolar process is divided into eight sockets or alveoli, corresponding in size and shape to the teeth; those of the molar teeth being broad, the canine circular, and the incisors somewhat compressed from side to side. The bases of the sockets of the roots of the first and second molars appear as eminences within the maxillary sinus. That of the canine tooth is the deepest, and forms the canine eminence on the facial border.

The *malar process* is broad, and is seen at the junction of the facial and zygomatic surfaces. It is directed horizontally outwards, and articulates with the malar bone.

Structure.—The body of the superior maxilla is composed of thin laminæ. The ascending process is compact, but the alveolar process is made up entirely of small-meshed but stout cancelli.

Articulation.—The superior maxilla articulates with the bone of the opposite side, the frontal, nasal, ethmoid, lachrymal, palatal, malar, and inferior turbinated bones, as well as with the vomer. It also joins the triangular cartilage.

Development.—Our knowledge of the development of the superior maxilla is in a less satisfactory state than that of any other bone. Its centres appear in membrane and soon coalesce. Writers agree, however, that separate centres appear in the alveolar arch, the nasal, facial, orbital, and malar portions. Inferences deduced from the study of comparative anatomy and structural defects lead us to believe that the incisorial portion arises from two centres of ossification, one on either side of the median line in the position of the premaxillæ of lower animals. Development begins as early as the sixth or seventh week. In complete cleft palate the incisorial portion is separated from the remaining portion of the bone of the side corresponding to that on which the cleft occurs, or on both sides if the clefts in the alveolar arch are double (bilateral). Moreover, grave lesions in the development of the face indicate that the lateral parts of the superior maxilla arise within the first pair of visceral arches, while the incisorial centres arise within the lower free edge of the median fronto-nasal process of the embryo which descends in front of the ethmo-vomerine septum.

When the premaxillæ unite at the median line, the pair may be denominated the *intermaxillary bone.* The suture between the premaxillæ may be detected until the sixth year, and on the hard palate as late as the adult period.

Remarks.—In diseased conditions the identity of the premaxilla is occasionally established. Mr. Hughlings Jackson[1] describes the case of a boy three years of age who suffered from severe inflammation of the mouth followed by the exfoliation of the right premaxilla, the maxilla proper not being affected. The bone contained two incisor teeth. Mr. Bryant[2] gives an instance of the same disease in an adult aged forty-four, from whom an exfoliation was secured which corresponded to the premaxilla.

The following is an exceedingly interesting case in this connection which came under the notice of the writer: A gentleman, aged sixty, was much annoyed by a defect which prevented his dentist fitting a plate for artificial teeth. The patient was edentulous, and had had from early childhood a cleft in the incisorial portion of the upper jaw, which, as he had been informed by his parents, was caused by the loss of bone following an attack of measles. The cleft was a little to the right of the median line, and extended upward to the floor of the nose and backward along the roof of the mouth about an inch. The sides of the cleft were for some distance in contact, but posteriorly a delicate probe could be introduced into the nose. The entire right side of the dental arch was more incurved than the left. Acquired malformation of the hard palate, the result of early loss of the left premaxilla, was diagnosed.

The fact that both upper and lower maxillæ are derived from membrane would apparently explain the rarity of cartilaginous tumors, and would equally make clear the meaning of the fact expressed by Agnew[3] as follows:—

"Fibrous tumors of the upper jaw are quite uncommon, although frequently met with in the lower maxilla. A considerable proportion of all the morbid growths of the lower jaw belong to this class."

The case described by Mr. Hutchinson,[4] in which a cartilaginous tumor of the upper jaw occupied the canine fossa, but did not grow from the bone, must be considered in every way anomalous.

The law of symmetrical distribution of diseased action is not without example in the upper jaw, though instances of it are rare. The cases of Lebert and Murchison (see the section on the Lower Jaw) also included lesions of the upper jaw. Fergusson,[1] in commenting on a case of tumor in the alveolus and median line of the upper jaw, says that disease in one maxilla is common, but it is rare to find it implicating both maxillæ.

Many diseases of the superior maxilla take their origin from the mucous lining of the maxillary sinus. A tumor growing in all directions from the sinus will encroach within on the nasal chamber, above on the orbit, without and forward on the face, and downward into the mouth. The most common form of distortion, or at least the most noticeable, is the obliteration of the canine fossa. At times the bone becomes thinned, and will crackle under the finger like a piece of parchment. In a case mentioned by C. H. Moore,[2] a tumor of the right superior maxilla, of about two years' duration, formed about the position of the canine fossa, where a conspicuous thinning of the wall ensued. This eventually gave way, and the fluid contained in the sinus escaped into the mouth. In other instances, the collection will open upon the cheek, as described by J. H. Howard.[3] At a later stage of cystic distension, the entire anterior wall of the sinus may bulge forward and give rise to deformity. After the anterior, the most yielding wall of the sinus is the orbital. As a result of pressure in this direction, the eyeball may be displaced and protrude, the conjunctiva becoming thickened and inflamed. Pressure toward the nose and toward the hard palate is relatively infrequent. The last-named writer mentions a case in which the nostril was thus encroached upon. It is a curious fact that cystic distension does not involve the lachrymal duct. Tumors of a fibrous and encephaloid nature, on the other hand, may cause overflowing of the tears from such involvement,[4] as well as paralysis of sensation in the affected part, as witnessed by Fergusson.[5] The origin of solid tumors involving the upper jaw is so obscurely localized that little of definite value can be written of it. That *necrosis* of so vascular a group of bones as those composing the upper jaw should occur in the degree seen in the following case is certainly very exceptional: In a male child, aged four years,

[1] Med. Times and Gazette, 681, 1862, part 2.
[2] Trans. Path. Soc. London, 1868; also Lancet, 1864, 153.
[3] System of Surgery, ii. 955, 962.
[4] Med. Times and Gazette, 1850, 231, part 2.

[1] Ibid., 1860, 35.
[2] Trans. Clinical Society of London, iii. 39.
[3] Ibid., v. 131.
[4] Dr. Mason Warren, Surgical Contributions; also Heath on Diseases of the Jaws, p. 256.
[5] Lancet, 1861.

a month after he had recovered from an attack of measles, an offensive discharge was announced from the right nostril. The right eye became prominent, and finally protruded conspicuously. The cornea sloughed, and the globe gave way. The right maxilla, the malar, and part of the sphenoid bone became necrosed. The child died at the end of eleven weeks of phlebitis of the ophthalmic vein, involving the base of the brain.

PALATAL BONE.

The palatal bone (figs. 5 and 6, Plate XX.) occupies the space which would otherwise exist between the superior maxilla and the pterygoid process. It is placed to the outer side of the nasal chamber and to the posterior part of the floor of the nose and roof of the mouth. It enters also into the composition of the floor of the orbit; and it assists in closing the posterior ethmoidal cells, and the inner border of the sphenomaxillary space and fissure. It is in the form of the letter L, with the angle produced downwards and the vertical member notched above. In addition to a palatal and vertical plate, it presents a pyramidal, an orbital, and a sphenoidal process.

The *palatal plate* corresponds to the plate of the same name of the superior maxilla. It is concave above to form part of the floor of the nose, and is nearly flat below, but smooth to enter into the construction of the roof of the mouth. Its anterior border is serrated for articulation with the palatal plate of the superior maxilla; the posterior is concave, to form the posterior border of the hard palate. Its inner border, when united with that of the opposite side, is produced posteriorly to form the *posterior nasal spine*. The junction of the horizontal and vertical portions of the bone is marked by an opening—the *posterior palatine canal*—and by a sharp ledge of bone extending inward from the base of the *pyramidal process*, to give attachment to the palatal aponeurosis.

The *vertical plate* extends from the floor of the nose to the level of the spheno-palatine notch. It is smooth externally, when it forms the internal boundary of the spheno maxillary fossa. Internally it is marked by two *crests*—the upper for the middle turbinated, the lower for the inferior turbinated bone. It is grooved along its posterior border (forming the *posterior palatine groove*) for the posterior palatine artery and nerve.

Two processes arise from the termination of the vertical plate—the *sphenoidal* and the *orbital*. Of these, the *sphenoidal* appears to be the continuation of the vertical plate. It passes upward and backward as a thin wafer-like lamella, and, curving inward at its extremity, lies along the inner border of the base of the internal pterygoid plate to join the vomer. It thus may be said to enter into the construction of the roof of the nose. The *orbital process* is more robust, and is hollow. It forms the anterior boundary of the *spheno-palatine notch*, and enters into the floor of the orbit posteriorly and the sphenomaxillary fossa. It articulates with the superior maxilla, the sphenoid, and the ethmoid bones.

The *pyramidal process* or tuberosity is an elongated wedge arising at the union of the vertical with the palatal plates. It is directed outward and backward to be received into the pterygoid notch of the sphenoid bone. It is marked for articulation with the internal and external pterygoid plates. Between these is a smooth surface which enters into the pterygoid fossa.

The spheno-palatine notch, which lies between the orbital and sphenoidal processes, is converted into a foramen by the sphenoid bone, or by a plate of the palatal uniting the processes.

ARTICULATION.—The palatal bone articulates with the bone of the opposite side, and with the superior maxilla, the ethmoid, the sphenoid, the inferior turbinated bones, and the vomer.

DEVELOPMENT.—The palatal bone arises from a single centre of ossification which appears at the seventh or eighth week.

EXPLANATION OF PLATE XX.

Fig. 1. The ethmoid bone, seen from the lateral aspect.
For "Christa galli" read "crista galli."
Fig. 2. The vomer, seen from the side.
Fig. 3. The superior maxilla, seen from in front and the side.
Fig. 4. The superior maxilla, seen from the median aspect.
Fig. 5. The palatal bone, seen from the lateral aspect.
Fig. 6. The palatal bone, seen from the median aspect.

Fig 1

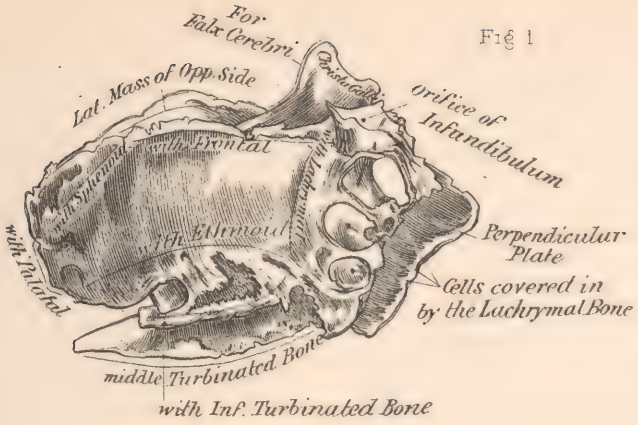


Fig 2



Fig 3.

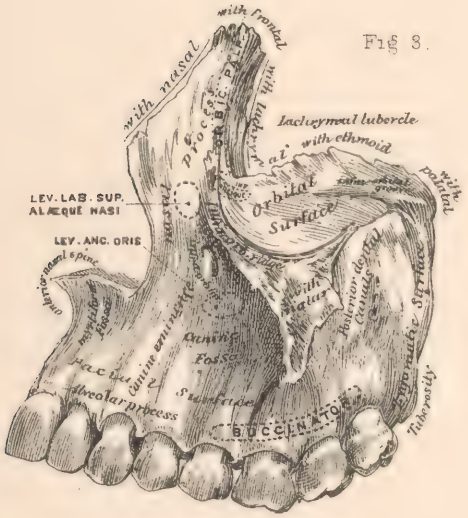


Fig. 4.

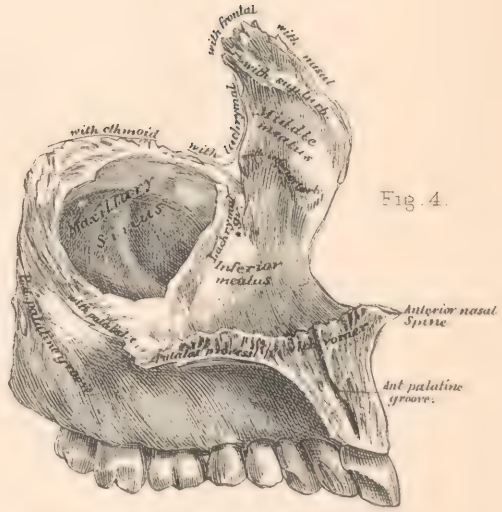


Fig 5

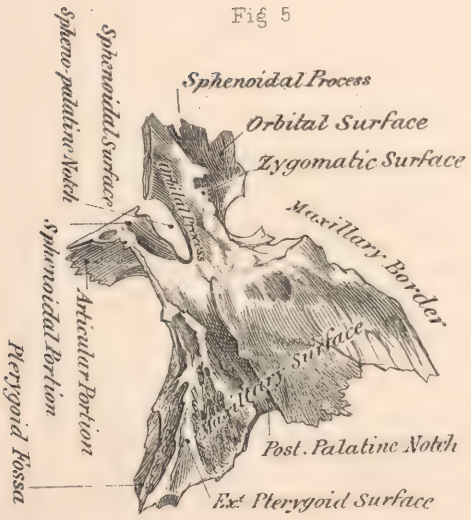
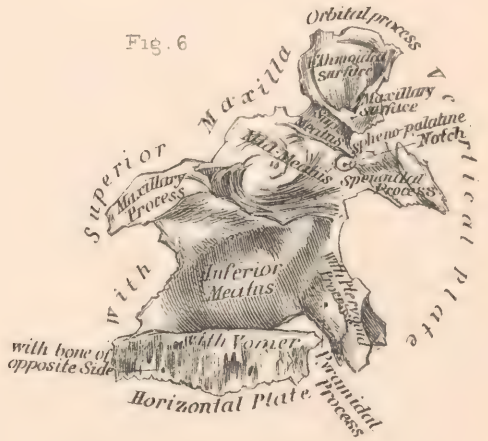


Fig. 6



T. Sinclair & Son, Lith.

INFERIOR TURBINATED BONE.

The inferior turbinated bone is an elongated scroll of bone appended by its outer border to the inner wall of the maxillary sinus, and to the lower crest of the palatal bone. It consists of a body and three processes, the *maxillary*, the *lachrymal*, and the *ethmoidal*. Its inner border, at its anterior edge, is fixed to the inferior crest of the nasal process of the superior maxilla. The bone is curved from within outward, presenting a convexity toward the nasal chamber, grooved for vessels and nerves. The entire bone is of papery consistency, and is marked by minute depressions and elevations for the retention of the mucous membrane.

The *maxillary* process is a hook-like process of a semicircular shape. Hence the name, sometimes given to it, of the *auricular process*. It is applied to the inner wall of the maxillary sinus, and serves to maintain the bone in position. The *lachrymal* process passes upward and forward to articulate with the inner portion of the lachrymal bone. The *ethmoidal* process arises on the same plane a little further back, to effect a junction with the uncinate process of the ethmoid bone. The lachrymal and ethmoidal processes aid in defining the nasal wall of the maxillary sinus.

Articulation.—The inferior turbinated bone articulates with the superior maxilla, the palatal, the ethmoid, and the lachrymal bones.

Structure.—Dr. H. J. Bigelow[1] describes in the inferior turbinated bone a special arrangement of the cancelli, which he believes allies it with the erectile cavernous tissue as seen in the penis. The cancelli of the bone freely intercommunicate by irregular apertures, are lined with connective tissue, and are subdivided by bands of the same material. During life, blood is supposed to occupy these spaces, and to assist in maintaining the cushiony appearance of the mucous membrane over the turbinated bones, as well as to aid in closing the nasal chambers during attacks of congestion of the mucous surfaces. A similar appearance is seen in the middle turbinated bone.

Development.—It arises from a single centre at about the fifth month.

Remarks.—The inferior turbinated bone, receiving its supply through the vessels supplying the mucous membrane covering it, is liable to errors of nutrition dependent upon bloodvessel changes. It is thus apt to become hypertrophied from catarrhal inflammations, and is frequently lost by necrosis through the inflammatory infiltrations of syphilis. Among civilized races it is almost invariably asymmetrical, the larger bone always lying in the larger nasal chamber. In congenital cleft of the hard palate, the bone descends along its obtuse lower border and tends to occupy the cleft. The anterior narrowed extremity is a rudiment of the prolonged "alinasal" of quadrupeds, which, as the name implies, reaches to the snout, and lies directly behind the space to the outer side of the nostril. This ridge in the human skull may reach the anterior border of the anterior nasal aperture, but generally ends at a point a short distance within.

[1] Boston Medical and Surgical Journal, 1875.

MALAR BONE.

The malar bone is situated at the side of the face, where it joins the cranium. It forms part of the temporal fossa and the anterior portion of the outer border of the orbit. It is associated with the zygomatic process of the temporal bone to form the zygomatic arch. It presents for examination a maxillary, a zygomatic, and a frontal process.

The *maxillary* process is broad and irregular. It articulates with the malar process of the superior maxilla. The *frontal* process forms the inferior third of the outer edge of the orbit, and articulates with the external lateral process of the frontal bone. A thin plate is directed inward from the frontal process its entire length, to join the great wing of the sphenoid bone. It is called the *orbital plate*, and helps to separate the orbit from the temporal fossa. A small portion of the orbital process ordinarily remains free, and enters into the outer border of the spheno-maxillary fissure.

The *zygomatic* process is a broad thick plate passing backward from the side of the bone. Its upper margin is horizontal, and is continuous with the frontal process to form the fronto-jugal border. Its course is oblique, and continuous with the malar ridge of the superior maxilla, to form the maxillo-jugal border. The zygomatic process articulates with the corresponding process of the temporal bone through a serrate suture.

The malar bone presents a *subcutaneous* or *facial* surface. It is smooth, somewhat convex, and furnished with several minute foramina for the malar branches of the ophthalmic nerve. A *temporal* surface is formed by the temporal aspects of the zygomatic and frontal processes, and an *orbital* surface

by the orbital aspects of the frontal and malar processes.

STRUCTURE.—The malar bone is composed of stout lateral plates with intervening cancelli.

ARTICULATION.—The malar bone articulates with the frontal, the superior maxilla, and with the zygomatic process of the temporal.

DEVELOPMENT.—The malar bone arises from two centres of ossification. Hilgendorf[1] states that this takes place not infrequently. Sometimes these centres remain distinct, when the malar bone has been described as "double."

REMARKS.—The facial surface between the orbital border and the position of the malar foramen is sometimes more convex than the rest of the bone. The temporal border of the frontal process quite commonly presents a process directed upward at the upper third in place of the swollen border, here commonly present.

THE LACHRYMAL BONE.

The lachrymal bone (figs. 1 and 3, Plate XXI.) is best seen upon the anterior portion of the inner wall of the orbit. It is a thin quadrilateral plate of bone lying in front of the os planum, back of the ascending process of the superior maxilla, below the internal lateral process of the frontal bone, and above the orbital plate of the superior maxilla. It is marked at its anterior third by a crest (*posterior lachrymal crest*) which aids in defining the *lachrymal groove*, the anterior wall of which is completed by a small crest on the ascending process of the superior maxilla—(*anterior lachrymal crest*). The groove is converted into a canal—the *ductus ad nasum*—by the aid of the nasal process of the superior maxilla and the lachrymal process of the inferior turbinated bone.

[1] Virchow's Archiv, 1879, 190.

Internally the lachrymal bone forms part of the outer wall of the nasal chamber. At this point the composition of the outer wall is complicated by the uncinate process of the ethmoid bone, which passes downward and backward to the inner side of the lachrymal bone; so that when the lachrymal bone is removed, this process occupies in part the opening; it thus serves to support the lachrymal.

The lower border of the lachrymal bone is thicker at the termination of the lachrymal crest than elsewhere, for the purpose of giving strength to the posterior wall of the *ductus ad nasum.* It articulates with the superior maxilla at the inner wall of the maxillary sinus, and with the anterior portion of the inferior turbinated bone.

ARTICULATION.—The lachrymal bone articulates with the frontal, the os planum of the ethmoid, the superior maxilla, and the inferior turbinated bones.

DEVELOPMENT.—The lachrymal bone arises from a single centre of ossification which appears about the eighth week.

REMARKS.—The lachrymal bone may be much reduced in size or be absent. For anomalies, see Gruber,[1] and Luschka,[2] Gegenbauer,[3] and the writer.[4]

THE NASAL BONE.

The nasal bones (figs. 2 and 3, Plate XXII.) are situated at the upper portion of the external nose. Each bone is longer than wide, and thicker above than below. It is smooth and gently convex from side to side on its facial surface, and concave upon the nasal, where it is grooved for the nasal nerve. The upper margin is serrated for articulation with the frontal bone, and at the nasal spine. The inferior margin is continuous

[1] Müller's Archiv für Anat. 1848, xiv. p. 413.
[2] Ibid., 1858, p. 304.
[3] Zeitsch. für Morphologie, 1881.
[4] Amer. Journ. Med. Sci., Jan. 1870.

EXPLANATION OF PLATE XXI.

Fig. 1. The lachrymal bone, seen from the median aspect.
Fig. 2. The inferior turbinated bone, seen from the lateral aspect.
Fig. 3. The lachrymal bone, seen from the lateral aspect.
Fig. 4. The malar bone, seen from the lateral aspect.
Fig. 5. The malar bone, seen from the median aspect.
Fig. 6. The inferior maxilla, seen from behind, and somewhat foreshortened.
Fig. 7. The inferior maxilla, seen from the side.

Fig. 1.



Fig. 2



Fig. 3



Fig. 4

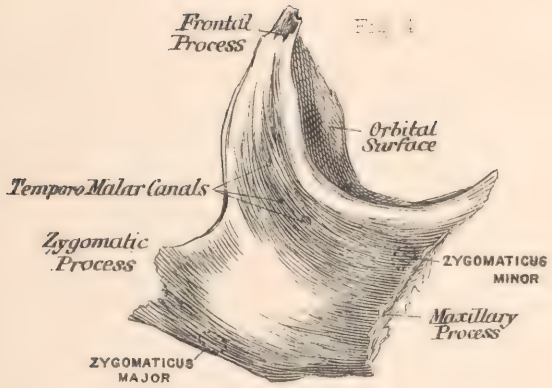


Fig. 5

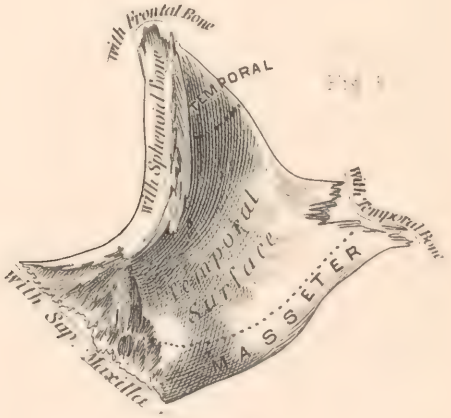


Fig. 6

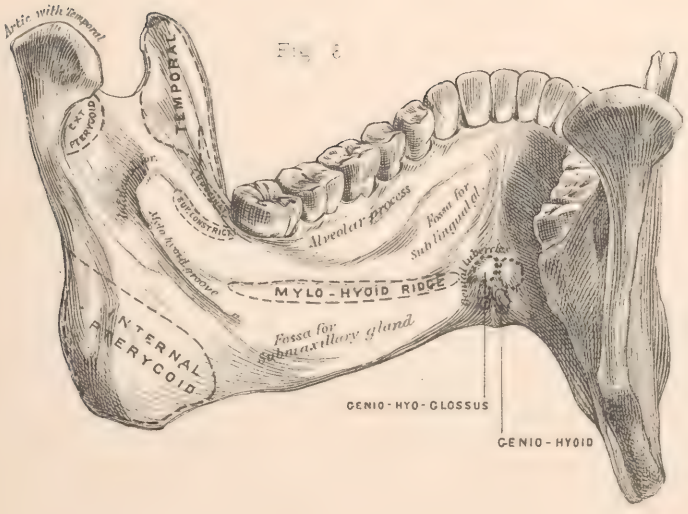
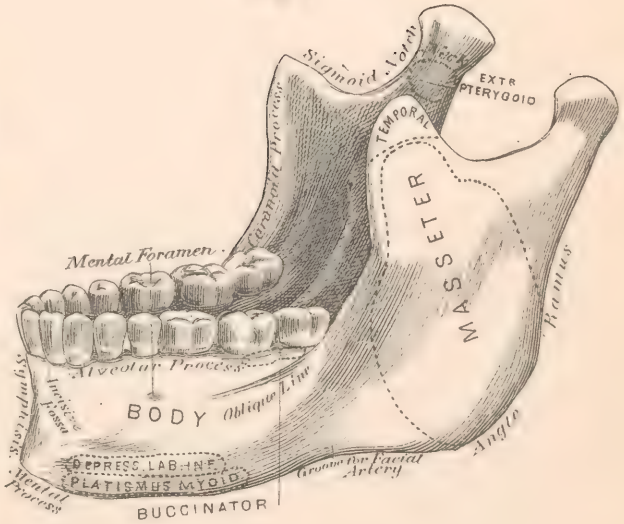


Fig. 7



T. Sinclair & Son Lith.

with the upper lateral cartilage of the nose, and is marked by a notch for the transmission of the nasal branch of the ophthalmic nerve. The median edge of the nasal surface forms a slight projection, which has received the name of the *nasal crest*.

Structure.—The nasal bone is of enormous relative thickness at its upper third: the lower portion is almost laminar in consistence.

Articulation.—Each nasal bone is joined to its fellow of the opposite side, to the frontal bone, to the ascending process of the superior maxilla, and to the perpendicular plate of the ethmoid bone.

Development.—The nasal bone arises from a single centre of ossification, which appears about the eighth week.

Remarks.—The articulation at the upper portion of the bones gives the nasals great strength in resisting the shocks of blows. The weight of such blows is in great part received by the cranium through the medium of the nasals. Blows received upon the side of the nose may break or displace these bones with comparative ease.—That the nasal bones are in part sustained in position by the perpendicular plate of the ethmoid bone is made evident by the sinking of the osseous part of the external nose in loss of this plate by necrosis. The place of the nasal bones when these are congenitally absent, as is infrequently the case, is taken by the ascending process of the superior maxilla. It may be composed of a single bone lying below the conjoined ascending processes of the superior maxillæ.[1] In the cyclops variety of monster, which is characterized by an imperfect development of all the parts lying between the orbits, the rudiments of the nasal bones occupy a narrow projecting mass of skin-covered tissue entirely separated from the superior maxilla and the ethmoid bone, but in continuity through the normal attachment with the frontal bone.

THE INFERIOR MAXILLA.

The inferior maxilla or lower jaw (figs. 6 and 7, Plate XXI.) is the largest and most massive bone of the face. It forms the boundary of the under part of the anterior and the lateral region of the face, where its lower border can be defined under the skin. It consists of a horizontal arch, with its curves directed in front and its sides elevated at an angle behind. The bone is moved on the base of the skull at the temporal bone by powerful muscles.

The lower jaw is composed of two halves; after their union it is convenient to divide the bone into a body, or horizontal portion, and two ascending portions or rami.

The *body* of the bone laterally is marked above by the edge of the *alveolar process*, and below by a thickened, rounded border. In the median line at the point of union of the primitive halves is a linear ridge —the *symphysis*. The widened and projecting basal extremity of this line is called the *mental process*. At the side of the symphysis, on a line with the lateral incisor tooth, is the *incisor fossa*, from which the Levator Labii Inferioris arises. Below this point, and to its outer side, is a shallow depression for the Depressor Anguli Oris muscle. The line of insertion of the Platysma Myoides muscle lies below the latter, on the basal border. Opposite and below the interspace between the second molar and first bicuspid, and about midway between the basal border and the teeth, is seen the *anterior dental foramen*, which affords exit to the inferior dental nerve and artery. The basal border of the body near the ramus is grooved for the reception of the facial artery. Extending obliquely upward and backward to the anterior root of the coronoid process is the *external oblique* line.

The median side of the body is conspicuously divided by an oblique ridge, which extends from the base of the coronoid process downward and forward. This has received the name of the *mylo-hyoid ridge*, and serves for the origin of the Mylo-Hyoid muscle. Between this ridge and the molar teeth slips of the Buccinator and Superior Constrictor muscles are attached. At a point below the canine teeth, a smooth depression supports the anterior border of the sublingual salivary gland. Below the mylo-hyoid ridge, a small groove running nearly parallel therewith receives the mylo-hyoid nerve and artery. A well-marked oval depression near the basal border anteriorly is for the insertion of the Digastric muscle. At the lower part of the symphysis are found *the genial tubercles*, ordinarily composed of four processes—two on either side of the median line. The superior process is for the origin of the Genio-Hyo-Glossus, and the inferior for the Genio-Hyoid muscle.

The *ascending portion*, or *ramus*, is imperfectly defined from the body anteriorly. Posteriorly it pre-

[1] J. Van der Hœven, Jr., Zeitschr. für Wissenschaftliche Zoologie, xi., 1862, p. 138.

sents a robust, rounded border, which is separated from the basal portion of the body by the *angle*. The outer surface of the ramus is in great part roughened for the attachment of the Masseter muscle. It presents two conspicuous processes, the *coronoid* in front and the *condyloid* behind. Between them is a deep hollow, *the sigmoid notch*. The median aspect of the ramus is conspicuously marked by the *posterior dental foramen* for the entrance of the inferior dental nerve and artery. The anterior margin of this opening is produced into a thin plate of bone, pointing backward, which gives attachment to the deep fold of deep fascia known as the internal lateral ligament. The canal between the anterior and the posterior dental foramina is termed the *dental canal*. It passes beneath the alveolar process, and sends veins and bloodvessels to the teeth. At its beginning it lies near the inner surface of the bone, but towards the first molar tooth it holds a more central position in the jaw, and ends abruptly externally at the *mental foramen*.

The *coronoid process* is flat and pointed. It is directed slightly forward. It is thin at its upper portion, but thicker below. Its front edge is nearly straight, and presents at its base behind the third molar tooth a groove, within which is held a slip of the Temporal muscle, as well as the Buccinator muscle. Its posterior edge is thin, and continuous with the curve of the sigmoid notch. The lateral surface is devoted to the insertion of the Temporal and Masseter muscles, and the median to the Temporal alone.

The *condyloid process*, more massive than the coronoid, is a continuation of the posterior free margin of the ramus. It presents for examination a *neck* and an *articular* surface. The neck corresponds to that portion of the process directly below the articular. It is compressed from behind forward, and receives at its inner portion a shallow depression for the External Pterygoid muscle. The outer margin of the neck is marked by a minute rounded process, the *tubercle* for attachment of the external lateral ligament. The articular surface is convex from before backward, abruptly arched from within outward. It is often angulated at a point answering to the axis of the ramus. The articular surface is directed inward and somewhat backward. The production of the lines of inclination of the two surfaces would cause them to intersect each other at the anterior margin of the foramen magnum.

Remarks.—The inferior maxilla can be studied with great advantage for practical purposes from the following points of view: (*a*) As divided into a right and a left half; (*b*) as divided into the alveolar portion as one part, and the remainder of the bone as another; (*c*) as divided into a region of muscular impressions as one part, and the remaining non-muscular region as the other; (*d*) as divided by the mylo-hyoid ridge into *facial* relations (*i. e.* all the parts above the ridge and the entire outer surface of the bone) and *cervical* (*i. e.* all the parts below the ridge); (*e*) as compared with a long bone, especially with reference to the localization of tumors.

(*a*) *The lower jaw as divided into a right and a left half.*—The lower jaw, in common with other symmetrical parts of the skeleton, exhibits those curious connections between physiological and morbid action often witnessed in the long bones. This symmetrical distribution of disease is disturbed, however, by the union of the halves of the bone at the symphysis. It is probable that in lower mammals, such as the ruminants and the marsupials, in which the halves never unite, the symmetrical distribution of disease might be found better expressed than in man.

The following instances may be cited to show that disease *tends* to occupy the *sides* of the jaw rather than the median line, and that excesses of nutrition are apt to occur on either side of the symphysis in an equal degree. In confirmation of the latter statement, we may refer to those extraordinary developments of symmetrical hyperostosis recorded by Lebert[1] and Murchison;[2] and in proof of the former, to the clinical fact that growths of all kinds are vastly more common on the sides than on the median portion of the jaw. The only examples known to the writer, of a growth beginning on one side of the bone and passing across the median line, are the following: first, a tumor termed by Prof. Gross[3] hematoid which began on the left side just behind the cuspid tooth, and passed across the line of symphysis as far as the lateral incisor of the right; and second, the one described by Mutter,[4] which occupied the symphysis and about two-thirds of the left ramus of the bone. Hyrtl[5] alludes to a case of exostosis of the symphysis.

(*b*) *The lower jaw as divided into the alveolus as one part, and the remainder of the bone as another.*—This division is an important one to remember, for the following reasons: The alveolus is developed with the teeth and disappears with the teeth; it is an outgrowth from the jaw for a specific temporary purpose.

[1] Atlas, pl. xxxii. fig. 1.
[2] Trans. Path. Soc. London, xvii. 243, pl. 10, xii.
[3] System of Surgery, i. 485.
[4] Amer. ed. of Liston's Surgery, 299.
[5] Topograph. Anatomie, i. 324.

Jno. Hunter[1] declared that the "alveolar processes of both jaws should rather be considered as belonging to the teeth than as parts of the jaws."

It follows that all diseases of the alveolus are to be considered as dental in their significance. Thus epulis is peculiarly an alveolar disease. A tooth in any portion of the jaw other than that of the alveolus is as much out of place as though it were lodged in another bone. There is little doubt that the third permanent molar, when in the position so often assumed by it at the end of the alveolus, half within and half without the dental arch, with its roots, it may be, deflected within the compact and resisting tissue of the base of the coronoid process, acts as a foreign body; and as a splinter in the flesh provokes inflammation, so such a tooth is of necessity a fertile cause of diseased action about the angle of the jaw. Should a tooth be lodged beneath the alveolus, as in the encysted form, it either gives rise to chronic abscess or provokes those common tumors, the odontomes, which frequently are of such fearful import. Cystic disease about the angle of the jaw is so often excited by a misplaced third molar that the teeth should always be examined in attempting to diagnose this condition. In a case mentioned by Bordenave,[2] fetid matter from the collection about the wisdom-tooth escaped after removal of the second and third molars.

Dr. Mason Warren[3] describes a number of cases of cystic tumor of the angle of the jaw. In one of these the growth began by a swelling at the root of the third molar of the right side. By the end of several years it involved the whole right ascending ramus. It was of a globular shape, extended back under the lobe of the ear, and forward to encroach upon the cavity of the mouth. In another the growth extended backward into the parotid region, upward upon the face, and "inward to involve the right half of the palate, where it was covered by a highly irritable œdematous mucous membrane resembling that covering malignant growths in the same locality." There was a slight discharge of fluid through the remains of the socket of the last molar. This being enlarged, the cystic character of the growth was made clear. In a third instance, a growth of six years' duration, which attained the size of a hen's egg, began in the socket of the third molar.

It would be interesting to trace the connection between defects of the teeth-germs and congenital cystic tumor of the lower jaw, such as is described by Coate,[1] occurring on the right side of the lower jaw of an infant three months of age. Death ensued from exhaustion[2] following an operation for its removal.

That the body of the jaw is a growth distinct from the alveolus is shown in the study of cases of congenital defects of the bone. In the following rare manifestation of imperfect development characterized by permanent fixation of the two halves of the bone, we have, as the adult condition is attained, the jaw preserving the proportions of the infant as far as the body is concerned, while the teeth and alveolus are as well pronounced as in a normal jaw. Mr. Humphry[3] describes the case as follows:—

"The lower jaw is almost completely fixed, with the molar teeth clinched against the upper, so that there is no perceptible interval between them. The jaw is broad or natural at the angles, and the angular parts have descended nearly to their proper level; but the arch formed between the two angles is extremely small. Indeed, the body and the mental portions of jaw run forward scarcely at all, and do little more than pass from one angle to the other. The chin is in a plane two inches behind the alveolar edge of the upper jaw, instead of being a little in front of it. There has been, therefore, a failure, amounting to at least two inches, in the growth of the body of the jaw in length; and it is also less deep than natural. The failure, however, has not been shared in quite an equal degree by the alveolar portion. This forms a segment of a larger circle, taking a wider sweep, and, consequently, overhanging the lower part of the body of the jaw. By this means greater room is given for the teeth, which are as numerous and *as large as natural;* and they are disposed in a slanting fan-like manner, so as to bring the crowns of the molars and hinder bicuspids into contact with those of the upper jaw."

(*c*) *The lower jaw divided into muscular impressions as one part, and the rest of the bone as the remaining part.*—Both sides of each ascending ramus may be said to be large muscular impressions—the lateral for the Masseter, the median (less completely covered) for the Pterygoid muscles, while the tendon of the Temporal muscle embraces the coronoid process. The arch of the bone can be called, for the most part, a non-muscular area; for with the exception of the in-

[1] Palmer's Hunter, i. 4.

[2] Surgical Essays, Sydenham Series.

[3] Surgical Observations, with Cases and Operations. Boston, 1867, 72.

[1] Sydenham Retrospect, 1861.

[2] For a cystic tumor not apparently connected with the teeth, yet strictly alveolar, see R. Adams, Med. Times and Gazette, 1857, 484.

[3] Med.-Chir. Rev., 2d series, xxvii. 1862, 288.

sertion of the Digastric muscle at the small digastric fossa, and of the Genio-Hyoid group at the genial spine, the muscles here (viz., the Mylo-Hyoid muscle *within*, at the ridge of the same name, and the Depressor Anguli Oris and the Platysma Myoides muscles at the mental process *without*) constitute an unimportant element.

It is particularly with the ascending ramus that the muscular impressions are found to be of value in the study of lesions and diseased action. In the first place, the Masseters act as external cushions protecting the jaw from direct violence, while the Pterygoids act as internal cushions to prevent bilateral dislocation. In the second, the direct influence exerted on the shape of the angle by the Internal Pterygoid is often very marked. A condition known as incurvation of the angle is frequently seen in well-marked specimens of the lower jaw. It was at one time thought that this peculiarity stamped the individual as an example of a low type of man. It is a curious fact (only noteworthy from its liability to deceive in attempting such generalizations) that the same incurvation of the angle is a constant character in the jaw of the marsupials—a low group of the mammalia.

Another feature of importance is the fixity of the ascending ramus by the contraction of the masticatory muscles. Other things being equal, the position of elevation or depression of the lower jaw will make the difference between a dislocation and a fracture. If the jaw at the time of the injury be elevated, the bone is apt to be broken by the direct violence applied to it; if, however, it be depressed, it is more apt to be dislocated. The ensuing case is of value in illustration of this principle, since the lines of fracture were doubtless determined by the fixed position of the jaw.[1]

A young man whilst plowing was thrown down by his bullocks running away, and the coulter, catching his throat, tore away the entire horizontal portion and more than half of the right ramus of the lower jaw. "A lacerated wound extended from the right mastoid process across the throat nearly to the left angle of the jaw; this at its posterior origin had entirely divided the whole breadth of the Sterno-Cleido-Mastoid muscle; from the right angle of the jaw to near the chin it divided the floor of the mouth. It was also met by an oblique laceration from the left commissure of the lips, which had quite torn through and divided the cheek. The inferior maxilla was fractured on both sides, on the right more than halfway up the ramus. The bone thus broken and torn out of the face was very much denuded of soft parts, and at each fractured extremity was, to some extent, laid bare of periosteum." Six weeks after the injury, the right side of the face was paralyzed; the eye could not be closed, nor the mouth entirely.—The specimen embraced the entire horizontal portion of the jaw, and more than half of the ramus of the right side. The ramus had been fractured obliquely backward and downward from the root of the coronoid process to the middle of the posterior edge. On the left side the fracture extended obliquely across the angle, from behind the socket of the second molar tooth to just in front of the posterior part of the angle of the jaw.

According to Hamilton,[1] fracture of the condyloid process almost always occurs just below the insertion of the External Pterygoid muscle.

(*d*) *The lower jaw as divided by the mylo-hyoid ridge into two groups of relationships—one* above (*facial*), *the other* below (*cervical*).—The Mylo-Hyoid muscle is the floor of the mouth, and abruptly separates the inner aspect of the curve of the body from the rest of the bone. The relations of this region are entirely with the neck.

(*e*) *The lower jaw as compared to a long bone.*—The lower jaw resembles a long bone in having compact bone *without* and cancelli *within;* in having a well-defined canal (somewhat comparable to a nutritive foramen) entering it obliquely; and in having an active periosteum. It conspicuously differs from a long bone in the absence of an epiphysis. The bone is thus deprived of an epiphysial period, which is so prolific in morbid processes. The *ends* of the lower jaw (*i. e.* the articular surfaces) are peculiarly exempt from disease, the very opposite to what is seen in long bones. The only known instance of restricted disease at these points is caries, with subsequent hyperostosis. Mr. Tatum[2] briefly describes a unique case of fluid in the temporo-maxillary articulation escaping into the external meatus following a lesion of the latter.—The lower jaw also differs from a long bone in retaining contact with mucous membrane. When in fractures of the lower jaw the gum is deeply lacerated, the fracture at once becomes compound. The ease with which this can occur, and the consequent frequency of this occurrence, place maxillary fractures in a group entirely distinct from that of other bones. It has been asserted (and on good grounds) that the contact of the air and saliva between the ends of the broken bone

[1] J. Thomson, Edin. Med. Journal, 1861, vii. 587.

[1] Treatise on Fractures and Dislocations.

[2] Lancet, 1860, ii. 536.

tends to provoke ostitis and suppuration, with their sequelæ, constitutional disturbance, and increased risk of pyæmia.—The methods of securing vascular and nervous supply are widely remote from one another. In the lower jaw the bloodvessels and nerves enter by a canal which is primarily a groove in the embryonic bone, and which in necrosis is probably included in great part within the thickened osteogenetic periosteum. The dental nerve and vessel are designed, in a word, for a special object within the jaw, as well as to give blood and nerve-supply to the bone; thus holding the same relation to the jaw that the hepatic artery and nerve hold to the liver. The lower jaw is, independently of the teeth, not a very vascular bone. It succumbs readily to attacks of necrosis, as much from this cause as from its peculiarly exposed situation.

The ostitis preceding necrosis in the lower jaw is almost always more marked than in a long bone, and the pain is greater. The latter symptom often resembles that of intermittent toothache, thus complicating the diagnosis. The swelling of the cheek and gums, the difficulty in mastication, and the dysphagia, as well as the increased activity of the mucous and salivary glands, are distinctive symptoms. The presence of a sequestrum may, according to Butcher,[1] induce vomiting and difficulty in speech and swallowing. Thus, we have as a result of a branch of a cranial nerve being held in connection with the products of inflammation—if it be not itself inflamed—an excitation of a larger circle of sympathies than can arise from analogous conditions within a long bone.

T. Holmes[2] mentions the occurrence of fatal hemorrhage from the lingual artery excited by a maxillary sequestrum.

Necrosis of the lower jaw, as a sequela of measles, scarlet fever, smallpox, and typhoid fever—diseases whose lesions are for the most part splanchnic—cannot be compared to anything seen in the long bones. The same remark is true of phosphor-necrosis. It will be remembered that this disease always invades the jaw through a carious tooth or open socket—proving not only that the direct contact of the poisonous agent with the cancelli is requisite, but that such contact is *possible* only in the jaws; for no such relationship of cancelli to an open surface is ever seen in a long bone. A transverse section of the compact structure of the jaw may be compared to a vase. The base of the vase is firm and thick; the sides become thin as they approach the brim, while the upper surface is open. If a tooth is removed, the cancelli are at once exposed. Applying this explanation to the shape of sequestra, it will be seen that a sequestrum of the lower jaw or an exfoliation from the ends of a broken bone must be more or less U-shaped, as the same specimens from a long bone are more or less cylindrical. This rule does not apply to syphilitic necrosis.

According to Stanley,[1] nine months are required to restore a lower jaw through the activity of its periosteum after the bone has been destroyed by necrosis.

The comparison between the lower jaw and a long bone is interesting in studying the subject of removal. The wide range of sympathies seen in ostitis and necrosis of the lower jaw is to be expected in excision of that bone. In the event of amputation of a limb proving fatal, we commonly find pyæmia or secondary hemorrhage playing a ghastly rôle. While these prodromes to fatal disaster are unfortunately not wanting in the other operation, we more frequently find erysipelas and shock the exciting causes of sudden death. In summing up the experience gained in seven amputations, J. W. Casack[2] says: "Fatal cases of diffused inflammation succeeding to operations in the vicinity of the base of the lower jaw are by no means infrequent." In one of his cases, the erysipelatous inflammation involved the parts about the larynx, death ensuing on the ninth day after the operation. Mr. Symes[3] narrates a case of excision which proved inexplicably fatal on the second day.

(*f*) *The lower jaw as determining the localization of tumors.*—From an anatomical standard, this subject, of great intricacy in other relations, resolves itself into a few simple propositions:—

1st. When a tumor originates within or beneath the gum, and involves the cancelli secondarily, it indubitably belongs to the alveolar group of morbid growths. The different varieties of epulis are thus anatomically restricted.

2d. Fibrous tumors, according to Nélaton, may either arise within the body of the bone, when by their growth they will encompass the bone, or, having their origin beneath the periosteum, they may protrude toward the affected side. The same writer affirms that they tend to develop toward the cutaneous rather than toward the mucous (oral) aspect of the bone. Fergusson[4] describes a fibrous tumor which lay inclosed

[1] Essays and Reports on Operative and Conservative Surgery. R. G. Butcher. Dublin, 1865, 307.

[2] Holmes's System of Surgery, iii. 645.

[1] Trans. Path. Soc. London, iii. 169.

[2] Dub. Hosp. Rep., iv. 1827, 1.

[3] Surg. Contributions, 21.

[4] Med. Times and Gazette, 1865, 141.

within the expanded and attenuated tables of the jaw. The central encapsuling fibrous tumor may involve the dental nerve, as described by T. Bryant[1] in a tumor which was removed from the left side of the body of the lower jaw of a boy nine years of age. It was of two years' duration, and followed a blow received six months before. The nerve was found running through the centre of the growth. It would appear that encephaloid disease may originate in the dental canal, judging by the case reported by Nunneley,[2] in which the disease was ushered in by numbness of the left side of the lower lip. This was followed by varying pains in the canine and in two adjoining teeth of the same side. The last molar was extracted with a view of relieving the toothache. The case, the nature of which now became evident, progressed rapidly to a fatal termination.

3d. The lower jaw being in the line of growth of epithelial tumors of the lower lip, secondary cancers from that source are not infrequently seen. In a case coming under the notice of the writer, the disease had progressed from the lip along the line of the right side of the horizontal portion, opening the oral cavity from the side and destroying the alveoli. The tongue, thus deprived of lateral support, lolled outward, and the saliva dropped continually upon the neck. Fortunately, these extreme degrees of destructiveness are rare, but the probability of secondary involvements of the lower jaw from neglected epithelial cancer should never be overlooked.

THE SKULL.

The skull (figs. 1 and 2, Plate XXII.) is composed of the *cranium* and the *face*. It is convenient to include between these divisions a third — the *cranio-facial* or *intermediate portion*.

The term cranium is often applied to the entire framework of the head, either with or without the lower jaw. In a more exact sense, the *cranium* is the *brain-case*. The *face* is a region made up of bones that are in contact with mucous membrane—the malar bone alone excepted—and affords protection to the visual, olfactory, and dental organs, besides defining the nasal and oral cavities.

The brain-case and the face are distinct in their development. The brain-case possesses a central tract—the cranio-basic axis—which corresponds in general direction to that of the chorda dorsalis. It consists of the basilar process of the occipital bone and the body of the sphenoid bone. The vomer and the perpendicular plate of the ethmoid bone represent parts of the cranio-basic axis projected into the face. The chorda dorsalis does not advance further than the posterior clinoid processes. The lateral portions of the occipital bone and the wings of the sphenoid bone arise in pairs from the axis. The nasal bones and incisorial portion of the superior maxilla descend from the primordial frontal process of the frontal bone. The remaining portion of each superior maxilla, together with the lower jaw, arises from the side of the base of the skull. Each of the facial bones not mentioned in the above category appears in its appropriate place as a separate ossicle having slight morphological significance.

THE CRANIUM.

The cranium is divided into the *vault* and the *base*.

The Cranial Vault.—The cranial vault (figs. 1 and 2, Plate XXII.) is limited *anteriorly* by the supra-orbital arches and the fronto-nasal suture; *laterally* by the zygomatic arch, the orifice of the external auditory meatus, and a line running thence along the superior semicircular line to the occiput, which terminates the vault *posteriorly*. The *skullcap* or *calvarium* is defined by a horizontal section of the vault about one inch above the external angular process of the frontal bone.

The cranial vault is an ovoidal figure, broader behind than in front, and abruptly narrowed behind the external angular processes. It is slightly compressed at the sides at the temporal fossæ, and more or less expanded behind. The anterior portion of the vault is termed the *frontal region* or *sinciput*, the posterior the *occiput*, and the top the *vertex*. The *side* is made up in great part of the temporal fossa.

The *forehead* (sinciput) is defined inferiorly by the supra-orbital margins and the line of the fronto-nasal suture; superiorly, by a transverse imaginary line half-way between the frontal eminences and the coronal suture; and, laterally, by the temporal ridges. Directly between the orbits, and extending thence downward one-half the height of the inner margin of the orbit and upward about an inch upon the supra-orbital curve, is a smooth, rounded space, with a faintly convex surface, called the *nasal eminence* (glabella). This eminence corresponds to the anterior wall of the frontal sinus, and varies in size according

[1] Trans. Path. Soc. London, 1858, 352.
[2] Trans. Path. Soc. London, xiii. 1862, 215.

to the degree of development of the sinus. At the inner third of the supra-orbital arch of each orbit is seen the *supra-orbital notch*, which transmits the nerve of the same name. The notch is often converted into a foramen. A little further out from the border is the foramen for the supra-trochlear nerve.

The frontal and superciliary eminences lie upon the line between the eyebrows and the scalp, which limits from above downward the "forehead" of common language. Ordinarily the "forehead" is occupied by the fleshy fibres of the anterior portion of the Occipital Frontalis muscle. Occasionally a median depression marks the locality of the *inter-frontal suture*, formerly present at this place.

The back of the vault or *occiput* answers to the ascending portion of the occipital bone above the protuberance. It includes the lambdoidal suture, and is covered with the hairy scalp.

The *top* or *vertex* (crown) extends from an imaginary line half way between the coronal suture and the frontal eminence to the angle of the occipital bone. It embraces the parietal bones between the parietal eminences, and is marked in the median line by the *sagittal suture* (inter-parietal). It is everywhere smooth and convex, and covered by the hairy scalp.

The *side* of the skull is defined above by a line extending from the external lateral process of the frontal bone along the temporal ridge, and thence to the occipital protuberance, and below by a line answering to the lower limitation of the vault. It is made up in great part of the *temporal fossa*, so named from its occupancy in the undissected subject by the Temporal muscle. The fossa is formed by the temporal, parietal, frontal, sphenoid, and malar bones. It is deeply concave behind the orbito-temporal septum, at a point answering to the greater wing of the sphenoid bone and the pterion, and more shallow and convex posteriorly, where it is gradually lost upon the masto-occipital surface.

The anterior portion of the temporal fossa is deeper in the negro than in the Caucasian type. The temporal ridge is often represented in the adult skull by several faint lines, which answer to the lines of growth of the skull. The ridge in narrow skulls approaches its fellow of the opposite side to a greater degree than it does in broad skulls.[1] In congenital arrest of brain-growth and in low types of skulls, as in the Australian and in some paleo-lithic forms, this approach is decided, and resembles that constantly met with in the lower animals.

Measurements.—Draw a line from the fronto-nasal suture, and continue it over the top of the skull to the occipital protuberance. Cross this line by a second extending transversely from the upper border of the external meatus. Hyrtl finds that a line drawn from the middle of the sagittal suture to the anterior portion of the foramen magnum is about two to three inches less than the transverse line. It will be seen that the skull taken as a whole is most capacious at the junction of its posterior with its middle third. Measurements taken as suggested by curved lines are more satisfactory than those taken by means of callipers. A fixed relation should be found between the curves made by these lines in comparing measurements.

To aid in securing exact measurements of crania the following terms of Broca, as defined by Flower,[1] will be found useful:—

Alveolar point. The centre of the anterior margin of the upper alveolar arch.

Subnasal point or *Spinal point.* The middle of the inferior border of the anterior nasal aperture, at the base of the nasal spine.

Naison or *Nasal point.* The middle of the naso-frontal suture at the base of the nose.

Ophyron. A point situated immediately above the nasal eminence, or, more exactly, the centre of the supra-orbital line, which, drawn across the narrowest part of the forehead, separates the face from the cranium.

Bregma. The point of junction of the coronal and sagittal sutures.

Opisthon. The middle of the posterior margin of the foramen magnum.

Basion. The middle of the anterior margin of the foramen magnum.

Pterion. The point of junction of the frontal, sphenoid, parietal, and temporal bones on the anterior parts of the temporal fossa.

Stephanion. The point where the temporal ridge crosses the coronal suture.

Asterion. The point behind the mastoid process where the parietal, occipital, and temporal bones meet.

The vault of the skull differs greatly in degree of thickness. It may be exceedingly thin and brittle, or excessively thick.

The skull is thickest at the occiput, where its average measurement is three-quarters of an inch. It is thinnest at the temple and the roof of the orbit.

[1] Lucæ, J. C. G., Architectur des Menschenschädels, 1857, pl. xv.

[1] Osteological Catalogue of the College of Physicians and Surgeons, London, Part I., 1879.

In estimating the amount of force required to fracture the bones, as well as that required to conduct the operation of trepanning, the possibility of the occurrence of a cranial vault with thin brittle walls should never be forgotten. The vault is always thinner at the point of contact with the Pacchionian bodies upon its under surface than it is elsewhere.

While a general relation between the form and volume of the brain and the brain-case is conceded to exist no exact correlation can be detected between the two. The large side of the cranium may correspond to the smaller cerebral hemisphere. The inner and outer layers of the skull may separate widely; and the outer may not be concentric or parallel to the inner. The frontal sinus is of varying size, and bears no relation to the size of the related cerebral lobes; nor do the details of the interior of the brain-case correspond to the inequalities of the cerebral convolutions.

The Sutures of the Cranial Vault.—The sutures of the cranial vault are the *interparietal* or *sagittal*, the *fronto-parietal* or *coronal*, and the *occipito-parietal* or *lambdoidal*.

At the *sides* of the vault the lower ends of the coronal and lambdoidal sutures are seen. In addition the fronto-malar unites the external angular process of the frontal bone with the frontal process of the malar bone; and in the temporal fossa sutures are formed by the union of the antero-inferior angle of the parietal bone with the tip of the greater wing of the sphenoid bone (*parieto-sphenoid*), with the parietal bone and the squamous portion of the temporal bone (*parieto-squamosal*), and with the postero-inferior angle of the parietal bone and the mastoid portion of the temporal bone (*parieto-mastoid*).—The anterior portion of the temporal fossa is marked by the nearly vertical *fronto-sphenoidal* and *sphenoido-squamosal* sutures.

The *occiput* exhibits the greater portion of the occipito-parietal suture and a portion of the vertical limb of the *masto-occipital*.

The *forehead* retains sutures with the facial bones where the frontal bone articulates with the frontal, sphenoid, ethmoid, lachrymal, superior maxillary, and nasal bones. These several sutures can be readily named by combining the names of the two bones entering into them. The unscientific name "*transverse suture*" is sometimes given to all the sutures above named. The suture in the median line of the frontal bone of the skull of the infant forms the *frontal suture*. It rarely persists in the adult. The sutures of the vertex are variously dentated, while those of the base are slightly sinuate or straight. The degree of indentation is subject to great variety, yet presents a regular plan of distribution which may be thus epitomized: the parietal bones, where they first unite with one another, namely, about the middle third of the interparietal margin, exhibit dentations of a character different from those at the anterior and posterior thirds. At the anterior third they are not pronounced, and may be absent; at the posterior they are narrow and long.—The parietal bones unite with the frontal at the middle third of each half of the frontal bone, the upper and lower third presenting less coarse dentations. The dentations often end abruptly at the intersection of the coronal suture with the upper margin of the temporal fossa, the coronal suture below this point being, as a rule, sinuate or straight. The lambdoidal suture is coarsely dentate throughout. From the above it appears that the sutures are dentate in a degree proportionate to the places at which contact first occurred. In the region of the fontanelles (see succeeding section) the sutures are nearly straight or harmonic.—In the negro the dentations are less prominently developed than in other races.

The Fontanelles and Disappearance of the Sutures.—The fontanelles are the spaces between the incomplete angles of the cranial bones. They are occupied by membrane, which gradually becomes ossified as development advances. The fontanelles are four in number, and are formed in part by the four angles of each parietal bone. They are named the *median* and the *lateral* fontanelles. The *anterior median fontanelle*, or great fontanelle, lies between the antero-superior portions of the parietal bones and the halves of the frontal. It is of a lozenge or spear-head shape, and continues by its angles with the sagittal, coronal, and frontal sutural interspaces. It is the largest of the fontanelles. It disappears from the tenth to the fifteenth month, holding in this respect a close relation with the rapidity of the development of the entire osseous system. In a quickly closing fontanelle the teeth appear soon, and the child walks early. In cases of retarded development, on the other hand, the fontanelle remains open and larger, and indeed, though this is rare, it may persist through life.—The *posterior median fontanelle* is placed between the postero-superior angles of the parietal bones and the occipital angle. It is triangular in shape, and continuous with the lambdoidal and interparietal (sagittal) sutural interspaces. It is closed at birth or a few months after.—The *lateral fontanelles* lie at the antero-inferior

and at the postero-inferior angles of each of the parietal bones and the adjacent parts. They are small, unimportant, and disappear at birth. The hinder angle of the posterior lateral fontanelle is continuous with the interval between the divisions of the ascending portion of the occipital bone. Hyrtl records four instances in the adult skull of the persistence of a fissure answering in position to this angle. It is a striking fact that hernia of the brain never occurs through the fontanelles.

At birth the sutures of the vertex are so imperfectly formed that the bones can be made to slide slightly upon one another under moderate compression without injury to themselves or to the brain beneath. Such compression is inevitable during the delivery of the child, and is liable to take place to a greater or less extent during infancy. Post-mortem changes go on more rapidly in the brain when the fontanelles remain open than after they are closed. This fact is of medico-legal significance.[1] The protection secured to the sutures of the side of the skull appears to favor their early obliteration. Thus the coronal suture may be no longer traceable in the temporal fossa while yet distinct on the vertex. The sutures holding the temporal bone in position seem to disappear later than other cranial sutures, probably owing to the less pronounced organic union of this bone with the remaining cranial bones.

The time at which the sutures disappear varies with the different bones, with race peculiarities, and, as has been noted, with the rate of activities of the general ossific development. This rate is less active in cold than in warm climates. Other things remaining the same, the sutures disappear in the order of the completion of the development of adjacent parts. At fifty-five or sixty years, the sutures have become entirely obliterated. The sutures may separate under the distending force engendered by brain decomposition.[2]

Universal union of the cranial sutures constitutes *synostosis*. Should one or more of the sutures close while the skull is yet growing, deformation occurs. This is probably a frequent cause of variation in the shape of the vertex. The sagittal suture prematurely disappearing restrains the lateral expansion of the vertex, while forcing out the forehead and occiput. A skull thus deformed is known as the *scaphoid* or *boat-like* skull.

Premature sutural union is not of necessity evidence of the arrest of the development of the brain. Disappearance of the suture may result from excessive precocity of the osseous system, without any correlation existing between the growth of the brain and that of the skull. A distinct class of symptoms arises when the brain continues its growth within an unyielding brain-case, which is recognized by clinical writers.

The effect of a prematurely united suture upon the general nutrition of the bones adjacent to it is decided. The edges entering into the sutural line are thickened, while the substance of the bone a little distance from the line is thinned, and, in rare instances, is even perforated (see Parietal and Occipital Bones).

The deformities of hydrocephalus are largely determined by the condition of the sutures at the time of the occurrence of the disease. Fixation at the line of the sagittal suture causes bulging at the forehead and the occiput. Fixation at both the lambdoidal and the sagittal sutures causes vertical bulging at the line of the coronal suture, and enormous increase of the ascending portion of the frontal bone. Should the intra-cranial pressure announce itself prior to the closure of any of the sutures of the vertex, the several bones composing it become widely separated, and the fontanelles enormously increased in size.[1]

The bones of the vertex, arising as they do from membranous expansions, present a group of variations distinct from those that arise from cartilage. Prof. Turner[2] endeavors to account for this by stating that the areas of the different bones are less precisely defined, and that the process of ossification is more liable to disturbance in the former than in the latter. The modifications in arrangement are especially apt to occur along the lines of apposition of adjacent osseous areas, as, for example, along the sutural lines, or along the margins of the subdivisions of a bone proceeding from distinct centres.

The Wormian Bones (ossa triquetra). — The Wormian bones are variable in shape, number, and position. They are seen, in order of frequency, between the occipital and the parietal bones, at the junction of bones at the anterior third of the temporal fossa (*pterion*), and at the regions of the fontanelles. They are rare in the face, and are here almost confined to the roof and median surfaces of the orbit. They are unknown in the cranio-basic axis. It will thus be seen that the Wormian bones answer to the position of the membranous expansions, as opposed to

[1] Casper, i. 46, Syd. Soc. edition.

[2] Casper, l. c. i. 40.

[1] Rudolphi, Berlin. Abhandl. (Phys.), 1824, 121, figs.; also J. von d. Hoeven, Acad. Cæs. Leap. Nova Acta, xxix. 1862, figs.

[2] Edinburgh Royal Soc. Proc., v., 1866, 444.

the cartilaginous, and to the concave walls of extending spaces. They are, indeed, detached centres of ossification in the marginal area of growing membrane bones, which they aid in occupying intervening spaces among the bones themselves. They of necessity follow the rule of symmetry.

Portal alludes to the fact that the Wormian bones have been depressed in injuries of the skull, and have resembled fragments of bone pressing against the meninges. Sauceratte[1] reports a striking instance of error in diagnosis dependent upon mistaking the edge of a Wormian bone for a line of fracture. A trephine was about to be applied to the presumedly fractured point when the error was detected.

The Cranial Base.—The base of the skull presents two surfaces for examination—an interior and an exterior surface.

The *interior* base of the skull (fig. 1, Plate XXIII.; fig. 3, Plate XXIV.) is divided into three sections, which comprise the *anterior*, *middle*, and *posterior* cerebral fossæ.

The *anterior* cerebral fossa is composed of the horizontal plate of the ethmoid bone, and the body of the sphenoid bone in advance of the olivary body. At the sides lie the orbital plates of the frontal and the lesser wings of the sphenoid bone. The floor is thin and compact, slightly convex over the orbits, and concave for the olfactory grooves. It is pierced by the foramen cæcum, by the openings for the olfactory nerves, and by the optic foramen. It contains the anterior cerebral lobes and arteries, the olfactory tracts and bulbs, and the optic chiasm.

The *middle* cerebral fossa presents in the cranial axis the pituitary fossa and the clinoid plate; laterally, the great wing of the sphenoid and the squamous bone compose it. It is defined anteriorly by the lesser wing, and behind by the anterior aspect of the petrous bone. It presents everywhere a concave surface; is irregularly marked with a number of digitate depressions; is thinned at the eminence corresponding to the glenoid fossa, and at a point a little in advance of the foramen ovale; is pierced by the anterior lacerated foramen, the oval foramen, the spinous foramen, the hiatus Fallopii, and the termination of the carotid canal; and accommodates the middle cerebral lobe, the Gasserian ganglion, and the encranial divisions of the primal branches of the fifth pair of nerves.

The *posterior* cerebral fossa includes the following parts: At the middle line is seen the cranio-basic axis as far as and inclusive of the posterior clinoid processes. Behind this axis lies the foramen magnum, and beyond this in turn lie the internal occipital protuberance and the line extending thence to the foramen magnum. At the side, the posterior aspect of the petrous portion of the temporal bone and the related mastoid portion are seen. The posterior cerebral fossa is marked by the jugular eminence, and by the lateral groove for the sinus of the same name. The skull is very thick at parts answering to the base of the lateral sinus on the occipital bone. The posterior cerebral fossa is pierced by the foramen magnum, by the hypoglossal canal, by the posterior lacerated foramen, by the internal auditory meatus, and by the mastoid foramen. It contains the medulla oblongata, the cerebellum, the basilar artery, and encranial portions of the cranial nerves from the third to the twelfth. That portion of the posterior cerebral fossa lying below the groove for the lateral sinus on the occipital bone may be called the *cerebellar fossa*.

The *interior* base of the skull conforms more nearly to the shape of the base of the brain than does the vault to its related brain surface. Injuries to the head may cause direct concussion and laceration from the violent contact of the brain against the interior base. According to Hilton,[1] when the blow is received at the posterior part of the skull, the whole mass of the brain being driven forwards from the momentum given to it by the blow upon the bones of the skull, the under surface of the anterior part of the brain rubs over the depressed and elevated surfaces which

[1] Mélange de Chirurgie, ii. 262.

[1] Lectures on Rest and Pain, 25.

EXPLANATION OF PLATE XXII.

Fig. 1. The skull, seen from in front.
Fig. 2. The nasal bone, seen from in front.
Fig. 3. The nasal bone, seen from behind
Fig. 4. The skull, seen from the side.

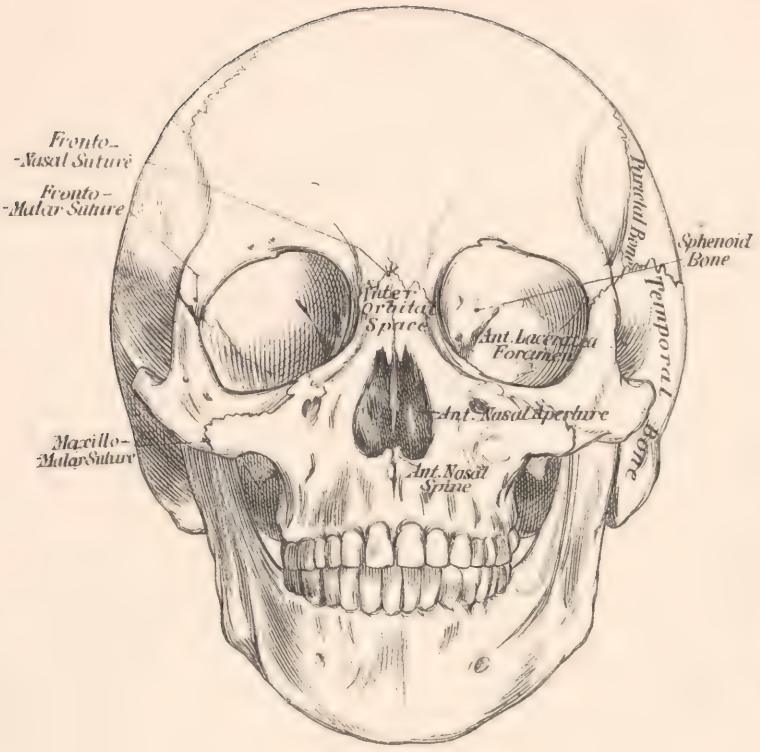


Fig. 1

Fig. 2



Fig. 3



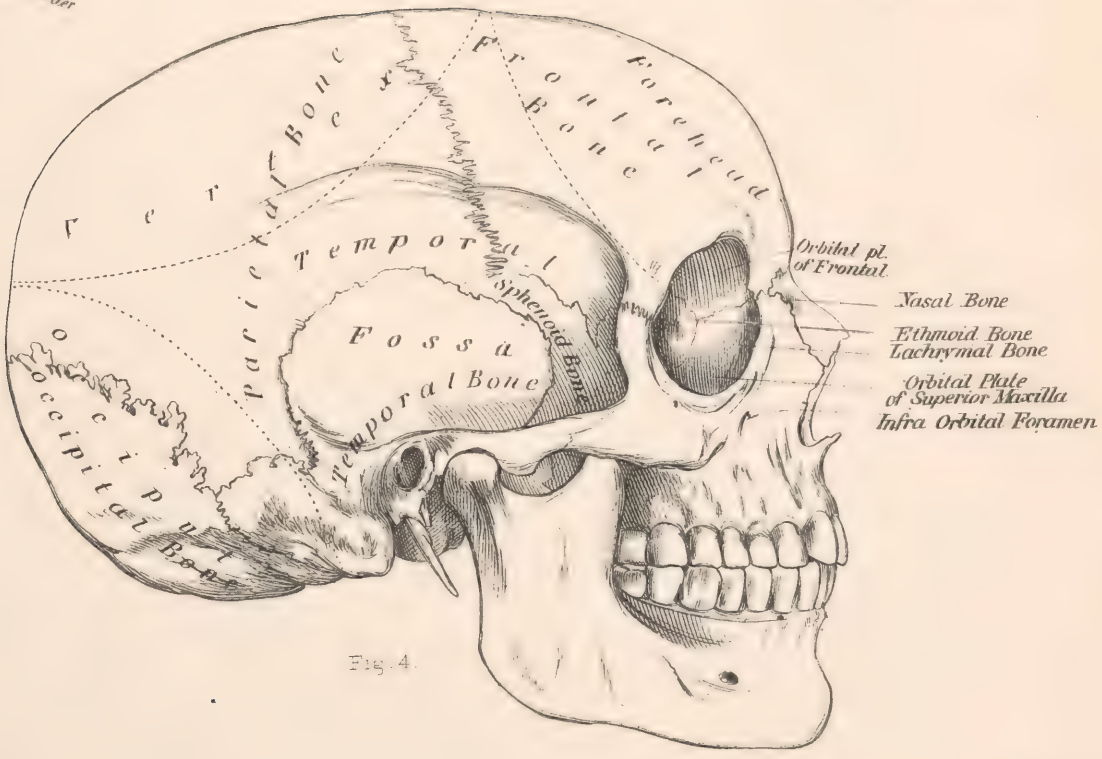


Fig. 4

T. Sinclair & Son. Lith.

constitute the anatomical features of the internal base of the skull.

The *exterior* base is the exterior of the parts forming the interior base. It is that surface remaining after the face has been removed. Anteriorly at the base of the forehead it is angulated to answer to the difference in level between the anterior and the middle cerebral fossæ of the interior base. The horizontal plates of the frontal bones and the cribriform plate of the ethmoid bone form one line of the angle, and the anterior (orbital) surfaces of the greater wings of the sphenoid bone the other. At the inferior border of the latter, namely, at the superior border of the spheno-maxillary fissure of either side, an imaginary line drawn backward to the posterior border of the foramen magnum (opisthon), and thence to the external occipital protuberance, completes the limitation of the exterior base. The figure resultant upon the union of these lines may be compared to a letter Z, the lower horizontal member of which is greatly prolonged. In a less exact manner a line extending from the external occipital protuberance to the fronto-nasal suture has been said to define the base.

A section made by removing the parts intervening between the lower limb of the Z and the free anterior end of the figure would pass through the roots of the pterygoid processes, the angular processes of the frontal bones, the vomer, and the perpendicular plate and ossa plana of the ethmoid bone.

Examined in detail, the exterior base of the skull presents for examination from before backward the following surfaces: The narrow and perforated cribriform plate of the ethmoid bone; the horizontal plates of the frontal, which are thin, brittle, and slightly arched, together with the orbital surfaces of the lesser sphenoidal wings; the section of the external angular process, showing spongy tissue; the smooth surface of the thick, spongy greater wing of the sphenoid bone—the junction of the horizontal and sphenoid surfaces, which is often marked by a number of minute foramina. Behind this region the body of the sphenoid bone, the bases of the pterygoid processes, the horizontal limb of the greater wing of the sphenoid, and the squamous portion of the temporal bone, are seen. Yet more posteriorly lies the cranio-basic axis, as here represented by the basilar portion of the occipital bone. The lateral portions are composed of the under surface of the petrous portions of the temporal bones and of the tympanic bones. The posterior basal surface is made up of the foramen magnum, of the occipital condyles, of the lateral portion of the occipital bone, and of the ascending portion of the same as far as the superior semicircular line.

The exterior base of the skull is marked by the lateral processes of the frontal bone, by the pterygoid, the spinous, styloid, mastoid, and jugular processes, and by the occipital condyles. It presents for examination the following fossæ: the pterygoid, scaphoid, glenoid, digastric, and the depressions in front and behind the occipital condyles.

The exterior base is pierced by the optic, anterior lacerated, oval, spinous, and posterior condyloid foramina. It receives the termination of the hypoglossal canal and the beginning of the carotid canal.

The structure and openings defined by the union of parts entering into the exterior base are: First, the *anterior lacerated foramen* between the greater and lesser wings of the sphenoid bone. It looks directly forward. Secondly, the Eustachian sulcus—extending inward and forward from the inner end of the glenoidal fissure to the body of the sphenoid bone. It is formed in part by the sphenoid and in part by the petrous portion. Its base is often incomplete. Thirdly, the *median lacerated foramen;* this is an interval between the tip of the petrous portion and the body of the sphenoid bone. It is occupied by fibro-cartilage during life. It is of variable size, and in the long and narrow skulls, as the skull of the negro, may be absent. Fourthly, the *petro-basilar groove.* This is a depression lying between the petrous portion and the outer side of the basilar process. It is filled with fibrous tissue during life, and is continuous with that filling up the median lacerated foramen.[1] Fifthly, the *posterior lacerated foramen.* This is formed by the union of the jugular grooves of the petrous portion of the temporal and the jugular groove of the occipital. It transmits the jugular vein, and the ninth, tenth, and eleventh cranial nerves. A bony septum (inter-jugular process, Henle) often separates the nerves from the nerve veins.

The posterior lacerated foramina and the jugular fossæ vary greatly in size in different individuals, and on opposite sides of the same individual.[2] A number of hypotheses have been from time to time announced according to which a definite connection between the size of the foramina and the activity of the brain centres and the special organs is traced. It has been claimed[3] that the foramina are contracted in

[1] The median lacerated foramen is not to be confounded with the termination of the carotid canal seen within the middle cerebral fossa.

[2] Theile, Zeitschr. für Rationelle Medicin, 1855, 339; F. O. Ward, Outlines of Human Osteology, 58; T. Dwight, Am. Journ. of Med. Sci., Oct. 1873; Rüdinger, Monatsch. für Ohrenheilkunde, 1875.

[3] Kasloff Oppenheim, Zeitschr. für die gesammte Med., Jan. 1844—abstract in Amer. Journ. of Med. Sci., 1844, 209, vol. viii.

maniacs and in suicides; and that subjective noises in the ears are at times associated with a narrowed foramen, especially when a wide bulbus of the jugular vein exists. An eddying current of blood is hereby created, it is thought, the sound of which is conducted to the labyrinth.[1]

The *carotid canal* is defined only when the bones are articulated. The inferior orifice is confined entirely to the petrous portion of the temporal bone. The superior orifice lies above the petro-basilar fissures at the middle lacerated foramen, as seen upon the interior base.

The base of the skull, as has been seen from the foregoing, will have connection with the face through the horizontal plate of the frontal bone, with the pharynx through the basilar portion of the occipital and the body of the sphenoid bone, and with the neck in the region behind the foramen magnum.

The base has been divided by writers on topographical anatomy by regions answering measurably to the above subdivision. Thus the palatal or facial—guttural or pharyngeal and occipital portions are described. But in practice little or no advantage accrues from following such an arrangement of parts. In seeking for the lesions of fracture, it is true, the base may be considered as a whole, but for all other clinical purposes it is best to ignore it. The palatal region is included in the face; the occipital becomes post-atlantal, and is included in the region of the neck. The so-called guttural region forms the base of the skull as distinguished from the adjacent regions.

Clinically restricted, when a tumor is stated as having its origin at the base of the skull, that portion immediately above the pharynx is intended. For the location of disease at the base of the skull the following division will be found worthy of consideration. By connecting the apices of the mastoid processes a line will be described which traverses each of the occipital condyles at its middle. This line will include the points of insertion of the muscles turning the head, as well as the region of the fulcrum at which the motion occurs. Behind and in front of this line lie the muscles which bow and retract the head. It therefore represents a region to be specially studied in all cases in which impairment of motion of the head or of the neck is a conspicuous sign. A second line extending forward from the digastric groove of the mastoid process to the inner plate of the pterygoid process will lie directly to the inner side of the oblique line of processes—the styloid, vaginal, spinous—and will retain all the foramina. Thus the jugular foramen and the beginning of the carotid canal lie directly upon the line, while the spinous and oval foramina lie immediately to the outer side. This line divides the under surface of the petrous portion of the temporal bone into two natural parts; the part to the lateral side of the line is related to the front of the neck and the face; that to the median side is connected with the pharynx. A tumor located at the lateral side of the line would involve the cheek-tissue, and in all likelihood be excluded from the base of the skull by the recorder. One arising from the median side would be as certainly described as connected with the base of the skull.

The Sutures of the Base.—The sutures of the base include the cranio-facial sutures; the *squamoso-sphenoidal* is seen traversing the zygomatic fossa; this division of the *squamoso-sphenoidal* suture is observed to be continuous with the *squamoso-tympanic* suture at the glenoidal fissure; in the median line is the *basilo-sphenoidal* suture. The straight, non-serrate *petroso-sphenoidal* suture lies at the bottom of the sulcus for the cartilaginous portion of the Eustachian tube. Next in order is the *petroso-basilar* suture at the bottom of the groove of the same name. It is a nearly straight, smooth junction. The horizontal limb of the *occipito-mastoid* suture is next seen. It is a nearly straight sutural line extending from about the centre of the digastric groove to the posterior lacerated foramen.

Structure.—In the occipital bone between the condyles and the jugular processes, in the petrous portion of the temporal bone in great part, and in the horizontal portion of the greater wings of the sphenoid the base of the skull is compact. It is spongy in the occipital condyles, in the basilar processes, in the pterygoid processes in great part, and in the jugular and the mastoid processes. The last two processes, together with the posterior projection from the base of the pterygoid processes bordering upon the middle lacerated foramen, are noticeable for the coarseness of the interspaces.

In fractures of the skull, the under surface of the frontal lobes of the brain and the rounded end of the spheno-temporal lobes are often found torn and bruised, even when the lines of fracture do not correspond to the seats of brain-lesion. This is not likely to occur under the cerebellum or pons, owing to the large lymph-cavities there present.

[1] S. Moos, Archiv of Ophth. and Otol., v. 478.

Remarks.—For all practical purposes, the basilar process and the body of the sphenoid bone form one structure, which may be called the cranio-basic axis. The spongy tissue here situate is often the seat of ostitis. It is found by surgical writers to be liable to caries, particularly that portion of it composing the body of the sphenoid bone. Caries originating in this locality will often involve the nasal chamber and excite inflammation of the pharynx, into which chamber particles of bone may be discharged.

Disease rarely attacks both base and vault in the same subject. If the vault is involved, the base escapes, and *vice versa*.

Pressure exerted from the accumulation of fluid in the descending horn of the lateral ventricle, as from hydrocephalus, creates distortion of the sides of the middle cerebral fossa, and, if the condition of the sutures permit, rotation of the temporal bone outward and downward, with resultant deformation of the basis of the skull and the side of the face. In such cases the external meatus lies on the base of the skull close to the occipital condyles, and a lateral pouch encroaches upon the sides of the face.[1]

In cretinism the deformations are in their initial forms basal, and pertain to errors of development and trophic change in the bones arising from cartilage at the cranio-basic axis. The cancellated structure of the basilar process of the occipital bone is exaggerated; the sphenoidal sinus is enlarged or malformed; the dorsum sellæ is steep; and the inclination of the plane of the basi-axis is variously changed from the normal plane. Accessory to these deviations, and in a measure dependent on them, ensue modified facial proportions and dental irregularity.[2]

THE CRANIO-FACIAL, OR INTERMEDIATE PORTION OF THE SKULL.

The union of the cranium and the face is effected at four places: at the zygoma, at the junction of the malar and temporal bones; at the outer wall of the orbit, at the junction of the frontal and malar bones; at the pterygo-maxillary junction, between the superior maxilla, palatal, and sphenoid bones; and finally at the junction between the vomer, the perpendicular plate of the ethmoid bone, and the bones articulating therewith (figs. 1 and 2, Plate XXIV.). Resulting from these lines of union a region is imperfectly defined on the exterior base of the skull, which may receive the name of the *cranio-facial region*, since its parts cannot be defined without including bones common to both the cranium and the face.

This region lies medianly to the zygomatic arch, and embraces two fossæ, the *zygomatic fossa* and the *spheno-maxillary space* (fig. 1, Plate XXIV.); and two fissures, the *pterygo-maxillary* and the *spheno-maxillary*.

The *zygomatic fossa* is bounded in front by a line produced downward from the under free border of the malar process of the superior maxilla; behind by the posterior free edge of the external pterygoid plate; below by the alveolar process posterior to the second molar tooth; and above by the ridge separating the Temporal from the External Pterygoid muscles. The bottom of the fossa is composed of the tuberosity of the superior maxilla, and the outer surface of the external pterygoid plate. Above it admits the horizontal portion of the greater wing of the sphenoid bone. It is continuous above with the temporal fossa and the orbit; behind with the exterior base of the skull; below, when the lower jaw is in position, with the parts about the coronoid process of the lower jaw; and medianly with the spheno-maxillary space.

The *spheno-maxillary space* (spheno-maxillary fossa) is the space between the free anterior surface of the upper half of the pterygoid process behind; the median part of the tuberosity of the superior maxilla, and a small portion of the orbital process of the palatal bone in front; and the outer wall of the nasal chamber (where it is defined by the thin and weak vertical plate of the palatal bone) within. The space has the form of a narrow triangle whose base is upward, where it is continuous with the orbit at the posterior end of the spheno-maxillary fissure. It is thus limited above by the *spheno-maxillary fissure;* while the *pterygo-maxillary fissure* limits it laterally. While the two last-named fissures aid in limiting the space, they serve as means of communication with the orbit and zygomatic fossæ respectively. The median surface or floor of the space joins the nasal chamber by means of the spheno-palatine foramen.

The spheno-maxillary fissure results from the formation of the orbito-temporal septum. It has no existence in animals in which the orbit and temporal fossæ are continuous, as in the dog and the lower animals generally.

At the base of the skull the position of the cranio-facial portion is indicated by the junction of the vomer with the body of the sphenoid. Clinical writers recognize that the relations of the rostrum of the

[1] Prescott Hewett, St. George's Hosp. Rep., i., 1866, 25, figs.

[2] F. V. Zillner, Nova Acta, l. c., xxvii., with figures; R. Virchow, Untersuchungen über die Entwickelung des Schädelgrundes, 1857.

sphenoid are with the pharynx, while those of the ethmoid spine are with the nasal chamber. Indeed, the anterior surface of the body of the sphenoid, including the sphenoidal sinuses, is as much facial in its relations as it is cranial.

Remarks.—The spheno-maxillary space will readily receive prolongations of tumors originating in the nasal fossa after the thin vertical plate of the palatal bone has been absorbed. Nasal polyp has been described as thus disposed; and Greco[1] has discovered a multiple form of morbid growth of obscure origin passing in the manner described from the nasal chamber to this space.

Mr. Prescott Hewett[2] describes a tumor growing from the exterior base of the skull that pushed its way through the spheno-palatine foramen into the spheno-maxillary space, and thence through the pterygo-maxillary fissure into the zygomatic fossa, and by this region round the zygomatic surface of the superior maxilla to appear upon the cheek. A specimen is preserved in Guy's Hospital, London, of a cartilaginous tumor at the base of the skull, which had advanced into the zygomatic and spheno-maxillary space. It had involved the orbits, nasal chambers, and the maxillary sinuses.

Langenbeck[3] diagnosed a fibroid tumor originating in the spheno-maxillary space, which involved the nasal chamber and naso-pharynx by passing medianly through the enlarged spheno-palatine foramen. The nasal septum was deflected to the right, and the left choana was obstructed. The mass also extended laterally to invade the zygomatic fossa, and superiorly to enter the orbit and to press the eye outward. In an operation for the removal of the tumor the parts were found enlarged to three times their normal size.

A small but noticeable crest is frequently seen on either side of the vomer, which aids in defining the posterior nares. This crest sometimes extends across the upper arc of the posterior nares so as to rest upon the sphenoidal process of the palatal bone. This outgrowth may receive the name of *the vomerine crest*. It serves to separate the roof of the pharynx from the cavity of the nose. Specimens have been met with in which the crest has shown evidences of thickening from inflammation.

[1] Archiv. de Méd., xxiii. 431.

[2] Med.-Chir. Trans., xxxiv. 47.

[3] Deutsche Klinik., 1861; also, Med. Times and Gazette, 1861 (abstract).

THE FACE.

The face (figs. 1 and 4, Plate XXII.) is that portion of the skull designed to protect the eyes, the nose, and the teeth, and in connection with the latter to define the osseous parts entering into the construction of the mouth.

The face is of a triangular figure. One of the sides answers to the exterior base of the skull in advance of the external auditory meatus, and may be called the *superior* border. Another extends from the upper margin of the orbits to the lower margin of the inferior maxilla, and constitutes the *anterior border* or *surface*. The remaining border of the figure is the *inferior*, and is defined by the lower margin of the inferior maxilla.

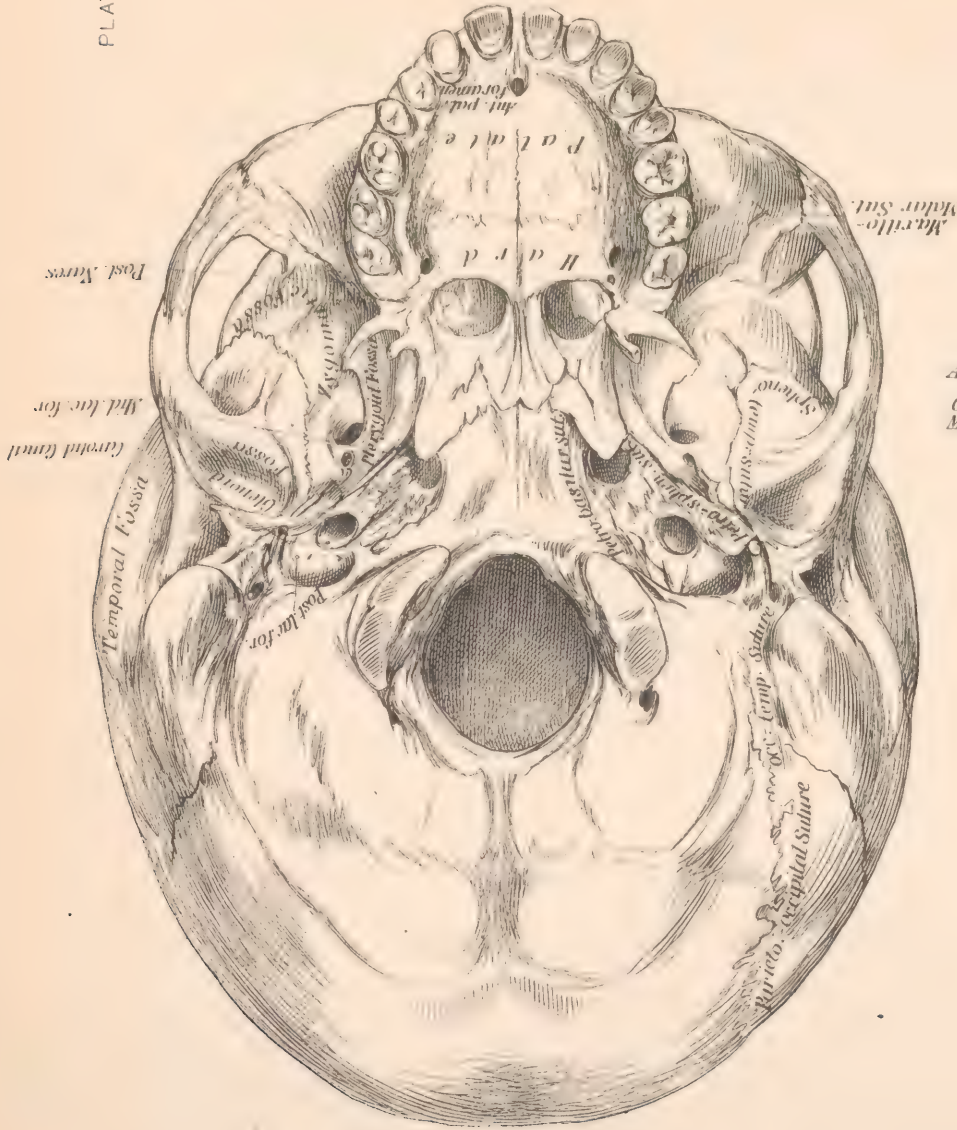
The Orbits.—The orbits are two conical cavities lodged for the most part in the face, but defined in part by the bones of the brain-case, and designed to accommodate the eyeball and accessory parts. Each orbit presents for examination a median (inner), and a lateral (outer), wall, a roof, and a floor.—The *median (inner) wall* is nearly straight, but slopes a little outward as it joins the floor. It is composed of the os planum of the ethmoid bone, and of the lateral surface of the lachrymal bone.—The *lateral (outer) wall* is more obliquely placed to the median line of the face than is the inner. It is composed in great part of the orbital surface of the greater wing of the sphenoid bone. In advance of this surface lies the frontal process of the malar bone. The outer wall is defined inferiorly in part by the spheno-maxillary fissure.—The *roof* of the orbit is slightly concave. It is composed of the orbital plate of the frontal bone, excepting at its apex, where a small portion of the lesser wing of the sphenoid bone is lodged.—The *floor* of the orbit is continuous with the median wall, but separated from

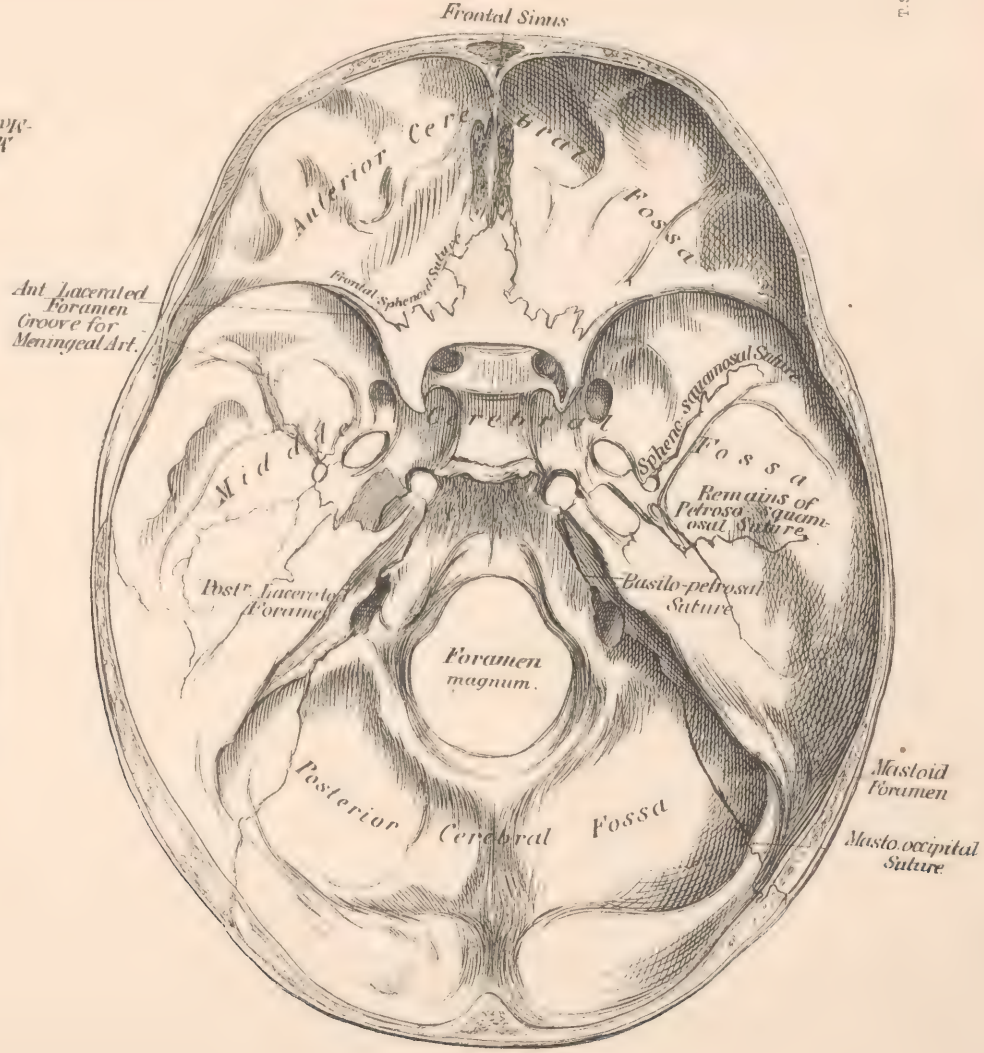
EXPLANATION OF PLATE XXIII.

Fig. 1. The skull, seen from beneath (exterior base).

Fig. 2. The base of the skull, seen from within (interior base).

PLATE XXIII





T. Sinclair & Son. Lith.

the lateral wall the greater part of its length by the spheno-maxillary fissure. In front the floor is completed by the malar bone, and behind by the orbital process of the palatal bone.

The orbit communicates with the cranial cavity by the optic foramen and the anterior lacerated foramen. The *optic foramen* lies at the apex of the orbit at the junction of the median wall and the roof. The *anterior lacerated foramen* extends from the median wall obliquely outward and inward along the junction of the lateral wall and the roof.—The orbit communicates with the temporal fossa through the spheno-maxillary fissure. The *anterior* and the *posterior ethmoidal* foramen are found at the junction of the median and lateral walls. The anterior ethmoidal foramen transmits the anterior ethmoidal artery and the nasal nerve; the posterior ethmoidal foramen transmits the posterior ethmoidal artery.

The Nasal Fossæ.—The nasal fossæ (fig. 2, Plate XXIV.) are two irregular cavities, one on either side of the septum. Each fossa is narrowed above, is higher before than behind, and presents for examination a lateral and a median wall, a roof, a floor, and an anterior and a posterior aperture.—The lateral wall is exceedingly complicated. It is composed of processes of the nasal aspect of the lateral mass of the ethmoid bone, of the inferior turbinated bone, and of the nasal aspect of the body and the ascending process of the superior maxilla. The lateral wall is uneven by reason of the position of the superior and middle turbinated bones (see the Ethmoid Bone, p. 131), as well as by the position of the inferior turbinated bone. The *middle meatus* is seen to be well defined between the lower margin of the middle turbinated bone and the upper margin of the inferior turbinated bone, and the *inferior meatus*, between the lower margin of the inferior turbinated bone and the floor of the nose. Under the term *agger nasi*, Meyer describes a crest extending from the upper margin of the middle turbinated bone forward along the lateral wall. The *median wall* of the nasal chamber is the nasal septum. It is composed of the following parts named in the order of their importance; the perpendicular plate of the ethmoid bone, the vomer, the maxillary and the palatal crests, and the frontal spine. The upper two-thirds of the inner wall is derived from the ethmoid bone. In the undissected subject the triangular cartilage completes the median wall anteriorly. Rarely if ever straight, the median wall inclines commonly to the left side at the vomero-ethmoidal junction. Occasionally it is incomplete.—The *roof* of the nasal chamber is very irregular. Anteriorly, *i. e.*, in advance of the cribriform plate, it is oblique from before backward and from below upward, and is composed of the nasal bone and the spine of the frontal bone. The cribriform plate occupies the middle third of the roof or more. It is straight or slightly concave. The remaining portion of the roof is derived from the sphenoid bone.—The *floor* is shorter than the roof, and is composed of the upper surfaces of the horizontal plates of the superior maxilla and the palatal bone. It is inclined slightly from before backward, and the premaxillary portion is often elevated above the level of the remaining portion.—The *anterior nasal aperture* (anterior nares) is a pear-shaped opening defined below and at the sides by the superior maxillæ, and above by the nasal bones. It thus forms the common opening to both nasal chambers.[1] Its plane is directed slightly obliquely from below upward and from behind forward. Its apex is on a level with the superior meatus and the sphenoidal sinus.—The *posterior nasal aperture* (posterior naris, choana) is smaller than the anterior by about one-fourth its height, and is defined without by the pterygo-palatine junction, within by the vomer, above by the vomerine crest (see p. 133) and the sphenoidal process of the palatal bone. The plane of the posterior nasal aperture is oblique from below upward and from before backward.

Each nasal chamber, in addition to the communication already mentioned, joins the orbit by the *ductus ad nasum*, the zygomatic fossa by the spheno-palatine foramen, and the brain-case by the foramina of the cribriform plate. It receives the outlet from the maxillary, frontal, and the sphenoidal sinuses, as well as the ethmoid cells.

For clinical purposes, the nasal fossæ are capable of being divided into three portions: the premaxillary, the maxillary, and the palatal portions. These names are selected from the surfaces occupied by the bones entering into the composition of the hard palate and the lateral walls of the nasal fossæ answering to the same. Thus, the *premaxillary portion* of the fossa lies in advance of the anterior palatal canal, and all the parts of the lateral wall in advance of the anterior border of the cribriform plate. The *maxillary portion* answers inferiorly to the surface between the anterior palatal canal and the suture between the maxilla and the palatal bones on the hard palate, and superiorly to the posterior border of

[1] When it is intended to name the outlet of a single chamber, the term *anterior naris* or *posterior naris* is permissible.

the cribriform plate. The *palatal portion* lies between this line and the plane of the posterior nares.

The Hard Palate.—The hard palate (fig. 2, Plate XXIII.), or roof of the mouth, is composed of the palatal aspect of the premaxillæ and the palatal plates of the superior maxillæ and of the palatal bones. The hard palate is of a U-shape, the limbs of the figure being slightly divergent. In the negro, the free hinder ends tend slightly to approach one another. The posterior free border is composed of two emarginate surfaces united at a median point, called the *posterior palatal process* or *spine*. The posterior palatal process may be absent when a triangular notch is seen in its place, or the two emarginations of the palatal bones are continuous with each other without interruption. The hard palate, when divided transversely (frontal section), exhibits the form of an arch, of which the pillars are constituted by the alveolar processes, and the top by the parts above named. At the median line, the hard palate behind the premaxillary portion is thicker than elsewhere. Occasionally a pronounced median swelling or flat ridge is seen, which forms a conspicuous projection, detectable with ease even in the living subject. On either side of the median ridge the hard palate is thin, and may be diaphanous. At the junction of the hard palate with the alveolar process a conspicuous longitudinal groove is seen for the accommodation of the palatine arteries and nerves. The hard palate is pierced anteriorly by the *incisorial foramen* so called. To speak accurately, two incisorial foramina, situated one on either side of the nasal septum, so far unite as to present but a single opening upon the hard palate. Each foramen transmits the anterior palatal branch of the superior maxillary nerve, as well as a small artery, the anterior palatine of its own side. Near the posterior border and at the base of the alveolar process, is the *posterior palatal foramen* for the posterior palatal artery and nerve. This foramen is protected in a measure by adjacent rugosities, and by a strong buttress-like ridge of the palatal bone. The hamular processes of the sphenoid bone can be readily felt in the living subject by passing the finger back of the wisdom tooth a little to the median side of the alveolar process. They serve as guides to the posterior limitation of the hard palate.

The Inter-orbital Space. — The inter-orbital space includes the nasal bones, the ascending processes of the superior maxillæ, the frontal bone below the level of the supra-orbital arches, and the lachrymal bone as far as the lachrymal crest. The *ductus ad nasum* thus pertains to the superficies of the face rather than to the orbit. The conjunction of the frontal and nasal bones and the ascending processes of the superior maxillæ in this space is such that enormous strength for resisting pressure and sustaining weights results. Fracture, or other injury, is rare here. Yet the lower half of the nasal bone is not infrequently either fractured or displaced. Ivory exostoses, for some unexplained reason, arise occasionally from the line of union of this space with the orbit.[1]

At a superficial glance, the modifications of the face, in order to accommodate the teeth, are restricted to the alveoli. But a more careful examination will show that the entire facial region is adapted to the forces employed in using the teeth. It has been seen that the bones of the face, with the exception of the lower jaw, are immovably united to one another and to the brain-case. To raise the lower jaw and to bring it against the upper so as to make these acts efficient in the seizing, the cutting, and the grinding of food, demand, on the part of the last-named structure, a power of so conducting the forces of occlusion as to avoid concussion of the delicate structures contained in the orbits and nasal fossæ.

The act of seizing and tearing food appears to demand greater strength than that of cutting or grinding it. The stout canine tooth conveys the shock along

[1] Consult Duka, Trans. Path. Soc. London, xvii., 256; also W. Watson, Ibid., 1868, xix., 310.

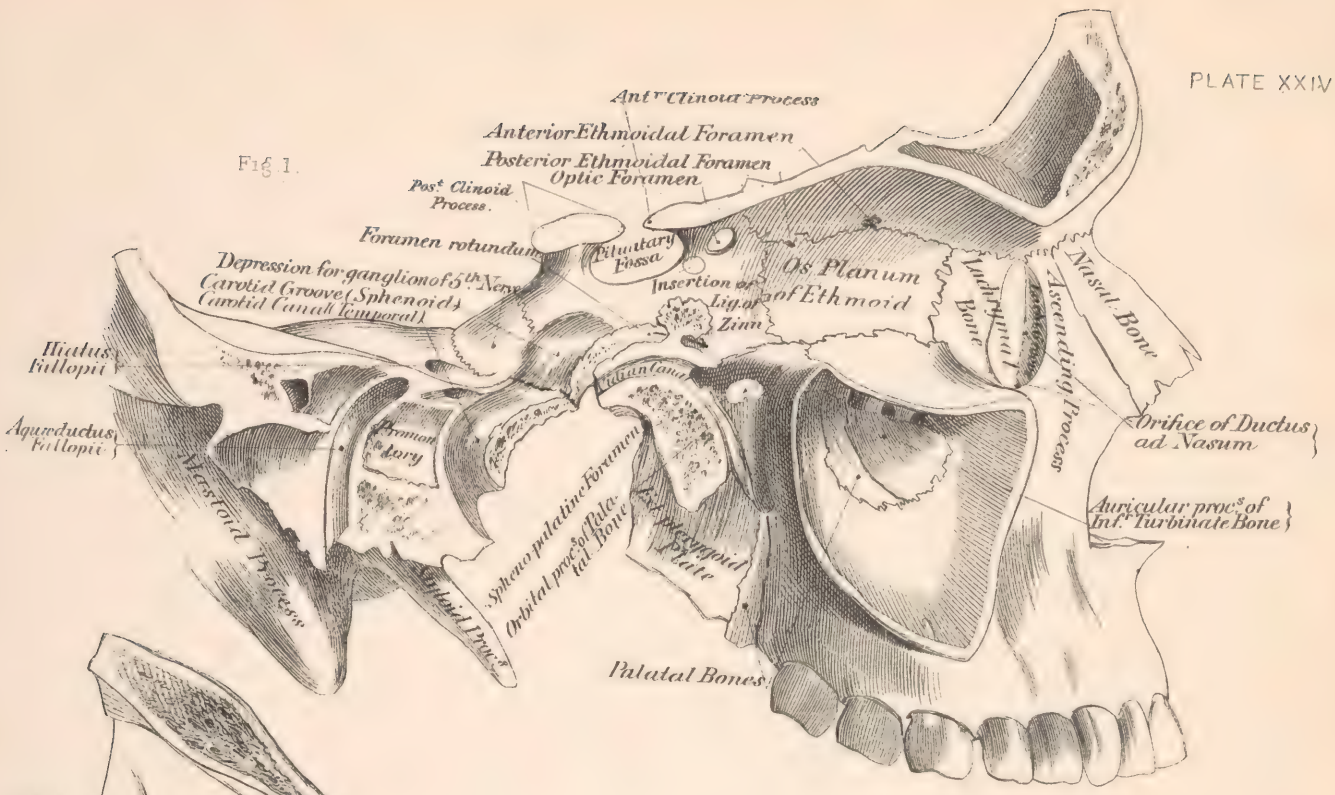
EXPLANATION OF PLATE XXIV.

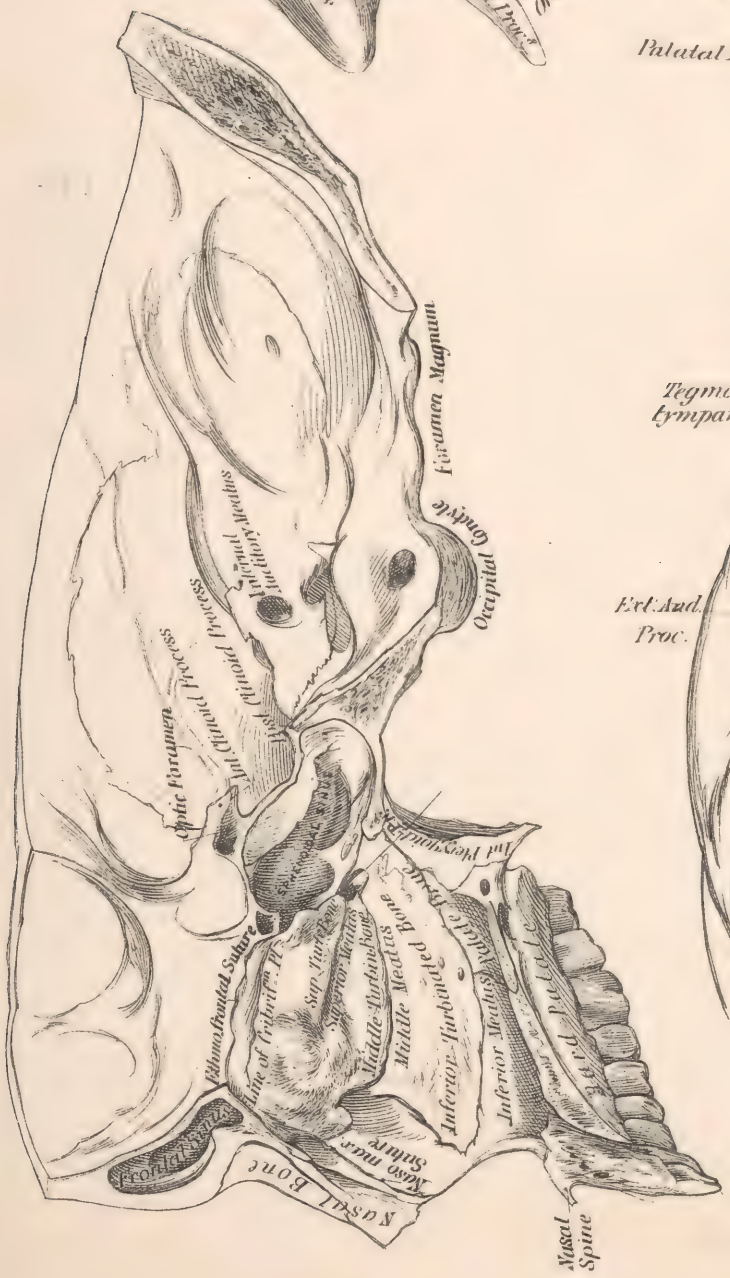
Fig. 1. Skull, seen from the side, exhibiting the profile view of the base; method of union of the bones of the brain-case and the face; together with the composition of the median wall of the maxillary sinus.

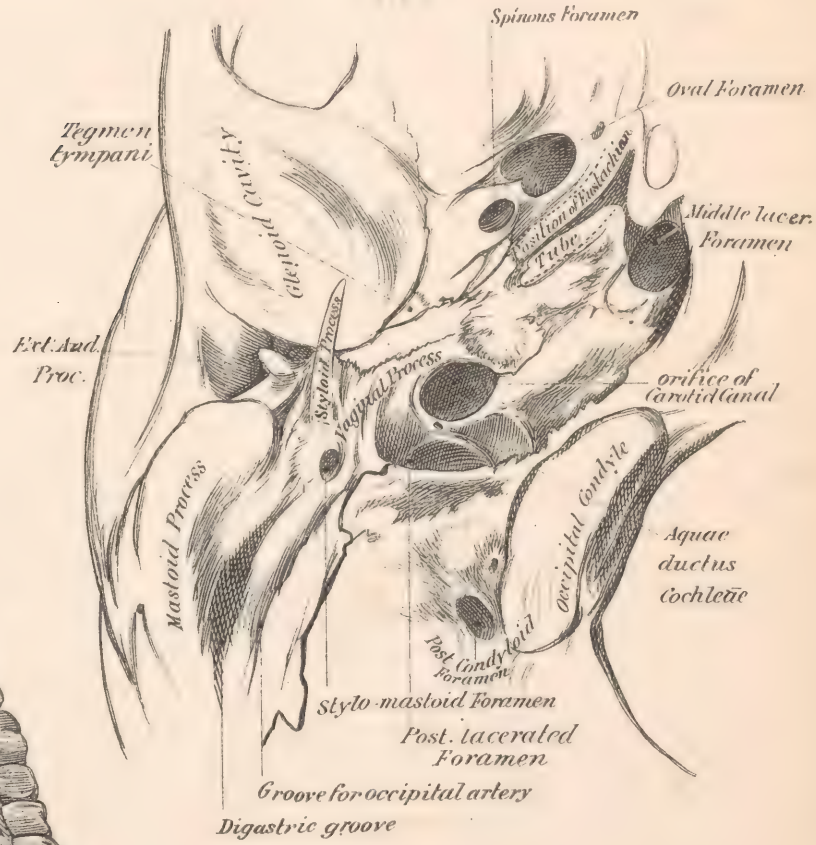
Fig. 2. Sagittal section of skull; the lower jaw and skull-cap are removed.

Fig. 3. The lateral region of the exterior base of the skull, slightly enlarged.

PLATE XXIV







T. Sinclair & Son, Lith.

the canine eminence to the ascending process of the superior maxilla, and thence it is received and distributed by the frontal bone to the cranial vault. The act of grinding demands a wide surface. This is secured by the divergent roots of the molar teeth, through which the force of the occlusion is diffused, and by the malar process, which conducts and distributes the shock to the zygoma and the cranial vault. The act of cutting demands little osseous support, and is accomplished entirely by the scissor-like action of the upper and the lower incisors against each other. The direct apposition of these teeth produces a decidedly unpleasant sensation. Disease and even death of the incisors may result from the habit (so common among seamstresses) of employing the incisor teeth in the position just named to bite off threads.

From the lines of conduction and resistance just mentioned, it is evident that there exist in the face two lines adapted to the conduction of shocks: one leading from the canine eminence through the ascending process of the superior maxilla, and the other from the malar process of the same bone to the malar bone. The spaces inclosed between the canine teeth, and between each canine tooth and the malar process of the corresponding side and the malar bones, are not adapted to convey or resist shock. It is within these spaces that the eyes and nasal organs are placed, and the nerves and bloodvessels lie. Even in the lower jaw we find in the adult the mental foramen on the same vertical line with the infra-orbital and the supra-orbital foramina. The repeated occlusions of the lower jaw against the upper may be said to maintain the shape of the latter. When the lower jaw is removed the alveolar processes fall inward, notwithstanding that the hard palate remains intact. This is well illustrated in a case reported by Ribes[1] of gunshot wound of the lower part of the face in which the lower jaw was torn away.

In extensive lesions of the face in which the lines of attachment between the immobile portion of the face and the brain-case have been severed, and yet the soft parts have been retained intact, the act of chewing becomes impracticable. The writer observed the case of a man who had incurred multiple fracture of the region of the face from a premature explosion of a blast: recovery from the immediate effects of the injury followed, but with absence of union between the face and the brain-case. The entire "upper jaw" was freely movable. The patient was sustained by liquid food. Dr. Fyffe[2] reports a case of dislocation of the bones of the face with fracture, including marked movability of the upper jaw during deglutition.

Surgical writers include in the term superior maxilla, or "upper jaw," parts embracing the palatal, inferior turbinate, and part of the ethmoid and the malar bones. The bones named are of necessity removed in the operation for excision of the superior maxilla. Viewed in this way the superior maxilla is said to be included between the inter-orbital space, the face as far laterally as the outer wall of the orbit, and the hard palate including the junction with the pterygoid process. The last-named junction is apt to be retained after complete severance at the other parts—and forcible depression of the partially detached mass is necessary before the final division can be effected.

Abernethy mentions a case in which the bones of the face were torn away from the skull, and left hanging merely by the optic nerves.

THE STRUCTURE OF THE SKULL CONSIDERED WITH SPECIAL REFERENCE TO THE EFFECTS OF INJURY.

The effects of injury upon the skull are varied by many circumstances, chief among which are the following:—

(1) The distribution of the spongy and compact tissue.

(2) The disposition of the cranial bones and their sutures.

(3) The direction from which the blow is received, as well as the position of the head at the time.

(1) *The Distribution of Spongy and Compact Tissue.*—The cranial vault is composed for the most part of *spongy tissue* overlying a thin compact layer. The spongy tissue is best developed at the occiput and at the sides of the vault. The squamæ, the sutural lines, the depressions for the Pacchionian bodies, and the forehead below the frontal eminences, are comparatively devoid of it. This spongy tissue of the vault has received the name of *diploë*. It is described as occupying the interspace between two plates, the outer and inner. The last named of these alone is worthy of the name, since the first named is inconstant in development, and may be absent. When present it is furnished with a number of minute openings for the escape of veins. The diploë is composed of a network defining irregular interspaces. These may assume a lamelliform arrangement, but are more frequently without apparent order. The diploic cells

[1] Dict. des Sciences Nat., 1818, xxix., 425.

[2] Lancet, 1863, ii., 64.

are filled with a marrow-like substance, together with some free fat. Ramifying among them are the *canals* of the diploë for the veins of the same name. The spongy tissue throughout the rest of the brain-case preserves the same general characters as that of the vault. It is well developed at the following localities: in the occipital bone at the region of the occipital protuberance, and in the median line thence to near the foramen magnum in the occipital condyles and the under surface of the jugular process; in the mastoid process; in the petrous portion of the temporal bone from the position of the posterior meatus to its tip; in the axis of the cranium from near the anterior margin of the foramen magnum to the position of the sphenoidal sinus, inclusive of the posterior clinoid plate; in the great wings and the pedicle of the external pterygoid plate of the sphenoid bone; and in the posterior pedicle of the lesser wing of the same name. In the facial region the spongy tissue is most conspicuous in the alveolar processes and the malar bones.

Compact bone-tissue is seen in the vault at the inner plate, as already mentioned. This layer is thick and smooth. It nearly corresponds to the shape of the brain, and presents at the base of the anterior and the middle cerebral fossæ a number of ridge-like elevations, which serve to give the plate increased strength. At the cranio-basic axis the inner plate is thinner than the outer. In some forms of hypertrophy the inner layer of the skull is enormously thickened; on the other hand, it may become lost in an osteoporotic condition which extends entirely through the skull-wall. Among other localities, the compact tissue is noticeable in the petrous portion of the temporal bone; in the cerebellar fossæ, the glenoid fossæ, the lesser wings and spinous processes of the sphenoid bone; and in the orbital plates of the frontal bone. Within the face all the bones entering into the nasal chamber and the walls of the maxillary sinus are papyraceous in consistence. In describing the course of the lines of fracture in the cranium, the character of the bone through which the fissures pass should receive the same attention as the direction of the fissures.

(2) *The Disposition of the Cranial Bones and their Sutures.*—The arrangement of the cranial bones and their sutures holds an exact relation to the mechanics of the skull. The union of the parietals by the interparietal suture converts the two parietal bones into an arch, the abutments of which are formed by the antero-inferior and the postero-inferior angles of the bones. Between these abutments, on either side, is seen the squamosal emargination. The plan of articulation of the abutments is significant of their use. The posterior is received into a V-shaped interval at the ascending portion of the occipital bone, and the re-entering angle is formed between the squamous and the mastoid portions of the temporal bones—producing a conjunction of sutural lines named the *stellion* of Broca. At a short distance below this point lies the occipito-mastoid suture. The anterior pillar of the abutment is received upon the anterior portion of the squama, and the greater wing of the sphenoid bone at the so-called *pterion* of Broca. At the base of the skull, in the line of the anterior abutment, lies the squamoso-sphenoidal suture. Rarely, a separate suture exists at the conjunction of the horizontal and ascending portions of the greater wing. It will be thus seen that the abutments of the arch formed by the parietal bone through the junctions effected by its antero-inferior and the postero-inferior angles rest upon parts of the base crossed by sutures. These sutures are harmonic, and are among the last to disappear. It is evident that a vibration passing from the vertex to the base by either of the abutments will be diffused by the time it reaches the base. From the position of the parietal bone with its slightly oblique direction from before backward and above downward, it would appear to facilitate the transmission of vibration along the posterior abutment. The distribution of the waves of vibration from both the anterior and posterior abutments to the face, the spongy tissue of the sphenoid, and the basilar process, is so effected as to protect the brittle petrous portion of the temporal bone. It is well to recall the free, coarsely-cancellated projections already remarked upon the basal region —viz., the mastoid, jugular, and other processes—as structures well adapted to receive and diffuse vibrations.

The sutures of the skull exert a marked influence in modifying injury during infancy and in youth. In adult life, the sutures may separate as the result of violent injury, but more commonly, particularly at that period at which the sutures have disappeared, the injuries occur in great measure entirely independently of the sutures. In individuals over fifty-five years of age, the study of fracture becomes one of directions of resistance and force without reference to the position of sutures. The fissures of fracture may even traverse large foramina.

(3) (*a*) *The Direction from which a Blow is Received.*—Fracture of the base of the skull will be found to correspond to the region of the vertex which has received

the blow. Thus fracture of the orbital plate of the frontal bone may follow a blow on the vertex at the ascending portion of the same bone. To facilitate the study of lesions resulting from blows received on the vertex Prescott Hewett[1] proposes a division of the skull into three segments or zones: an anterior zone formed by the frontal, the upper part of the ethmoid, and the wings of the sphenoid; a middle zone, by the parietals, the squamous, and the anterior surface of the petrous portions of the temporals, with the greater part of the body of the sphenoid bone; and a posterior zone, including the occipital, the mastoid, and the posterior surfaces of the petrous portions of the temporals, with a small part of the body of the sphenoid. —With the skull thus divided, the lines of fracture in the less severe cases are seen to be strictly limited to one or the other of these zones.—The region of the sphenoid bone, either alone or in combination with the other regions of the base, is that in which fracture most frequently occurs. Upon it the lines of conduction from the parietal arch are converged.

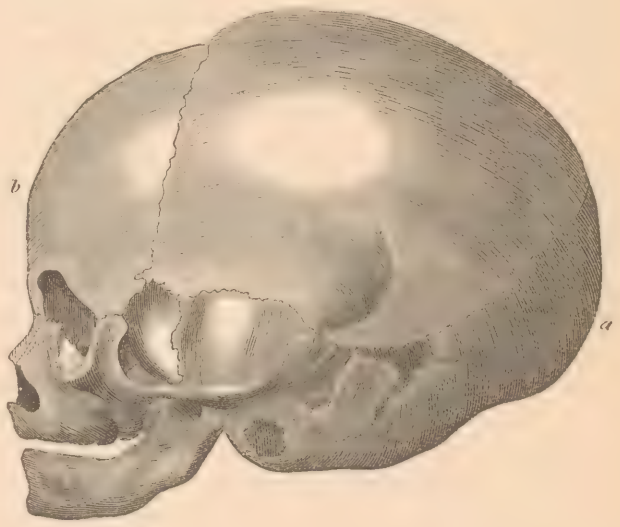
(*b*) *The Position of the Head at the Time of the Reception of the Blow.*—Some of the vibrations of blows received upon the vertex the skull will conduct either through the cranio-basic axis or the vertebral column. The manner in which this is accomplished will vary according to the position of the head at the time of the reception of the blow. The occipital condyles rest upon the atlas, and it is seen that each condyle is placed obliquely to the base of the skull, and consequently to its axis. Its anterior portion is thick, its posterior is thin. The weight of the skull tends inevitably to press the condyles within the concavity of the atlas, and it follows that the line of this pressure will be downward and inward, and more at the anterior part of the condyle than at the posterior. The convergence of the condyles tends to effect a union of the lines of support and to transfer them from the condyles to the axis of the skull; so in effect the basilar process and the body of the sphenoid bone receive the weight of the skull plus that of the face. The skull, however, is not balanced upon the vertebral column, but inclines to drop forward. This tendency is made necessary by the action of the post-cervical and the Sterno-Cleido-Mastoid muscles.

THE SKULL CONSIDERED IN RELATION TO AGE.

The description of the skull, as usually accepted, applies to that of the adult only. Numerous modifications of the account given in the preceding section are required to properly define the skull before development is complete, or after old age has set in. Two types will be especially mentioned in this connection. These may be called *the skull at birth*, and *the skull in extreme old age.*

The Skull at Birth.—The skull presents conspicuous prominences at the centres of ossification of the parietal and the frontal bones; the region of the occipital protuberance is markedly convex. The sutural lines are straight or nearly so. The fontanelles are all present. The skull presents many negative features, such as the absence of basal processes—the pterygoid processes alone excepted; the external auditory meatus is undeveloped; the jaws are edentulous, and the alveolar processes absent; the glenoid fossa is shallow, and affords little protection to the condyloid process of the inferior maxilla; the sinuses are rudimentary or absent. The peculiarities of proportion are numerous. The face constitutes but one-eighth of the entire figure, instead of nearly one-half in the adult. This is chiefly owing to the imperfect vertical growth of the bones. The orbits present deep depressions for the lachrymal glands. The entire cranium, as compared with the trunk, is large. Its length from the forehead to the occiput is great, as compared to its breadth. The breadth is great from one parietal protuberance to the other in proportion to the height. The brain-case is shallow in comparison with its capacity anteriorly and posteriorly. The orbit is much less deep at the median wall in the infant, owing to the imperfect descent of the median structures of the face; the proportions of the lateral wall are about as in the adult.

Fig. 68.



[1] Holmes's System of Surgery, vol. ii.

The Skull in Extreme Old Age.—The skull in old age presents many distinguishing features. The sutures are nearly or entirely lost (see p. 156). The walls of the brain-case are ordinarily thin from atrophy, while the teeth are absent and the alveoli absorbed. The skull is much lighter than in the mature adult, and the weight of the face is materially lessened. As a consequence, the skull is more readily balanced upon the vertebral column, thus making up for the withdrawal of the muscular power so essential to the maintenance of the head in man in his prime. The spheno-orbital septum, the roof of the tympanum, the orbital plate of the frontal bone, the os planum of the ethmoid, may be perforated. Other small processes, such as those tending to close the orifice of the maxillary sinus, may disappear. The pterygoid process is straighter than in the adult, and flattened in front. Owing to the absorption of the tooth-pits, it may descend far below the level of the hard palate. The prominence of the hamular process in consequence can be felt within the mouth during life. The outer pterygoid plate is often widened and extended some distance downward along the plane of the lower fibres of the External Pterygoid muscle. The triangular cartilage of the nose is often ossified; the sinuses are generally enlarged, though these may be even smaller than in the adult; and the jugular process is enlarged and inflated.

THE HYOID BONE.

The hyoid bone (figs. 1, 2, Plate XXV.), so called from its resemblance to the Greek letter υ, lies in the region of the neck between the tongue and the larynx, with its convexity directed forward and its concavity backward. It is superficial, permitting the general outline of the bone to be traced beneath the skin in the undissected subject.

The hyoid bone is composed of a body and two pairs of processes.—The *body* is somewhat quadrilateral in form, and is nearly twice as wide as high. The anterior surface is convex and well marked at the upper half by muscular impressions for the Genio-Hyoid muscles. These impressions look upward, and are sharply separated from the rest of the anterior surface which looks directly forward. The compressed median interval between these impressions is sometimes prominent and ridge-like. The posterior surface is smooth and deeply concave. The upper border is thin, and continuous with the inner and upper margin of the greater horn. The lower border is thicker than the superior, and is obscurely angulated laterally at the place of origin of the Omo-Hyoid muscles. The lateral border being continuous with the greater horn is seen only in the undeveloped bone.

The processes are two in number on each side, and have received the names of the greater and the lesser cornua or horns.

The *greater horn* is a long, irregularly club-shaped process, which is directed upward and backward, and is gradually narrowed posteriorly to end in a bulb-like tip.—The *lesser horn* is a small, peg-shaped nodule, ascending nearly at a right angle from the plane of junction of the body and the greater horn laterally. A joint ordinarily exists between the process and the rest of the bone.

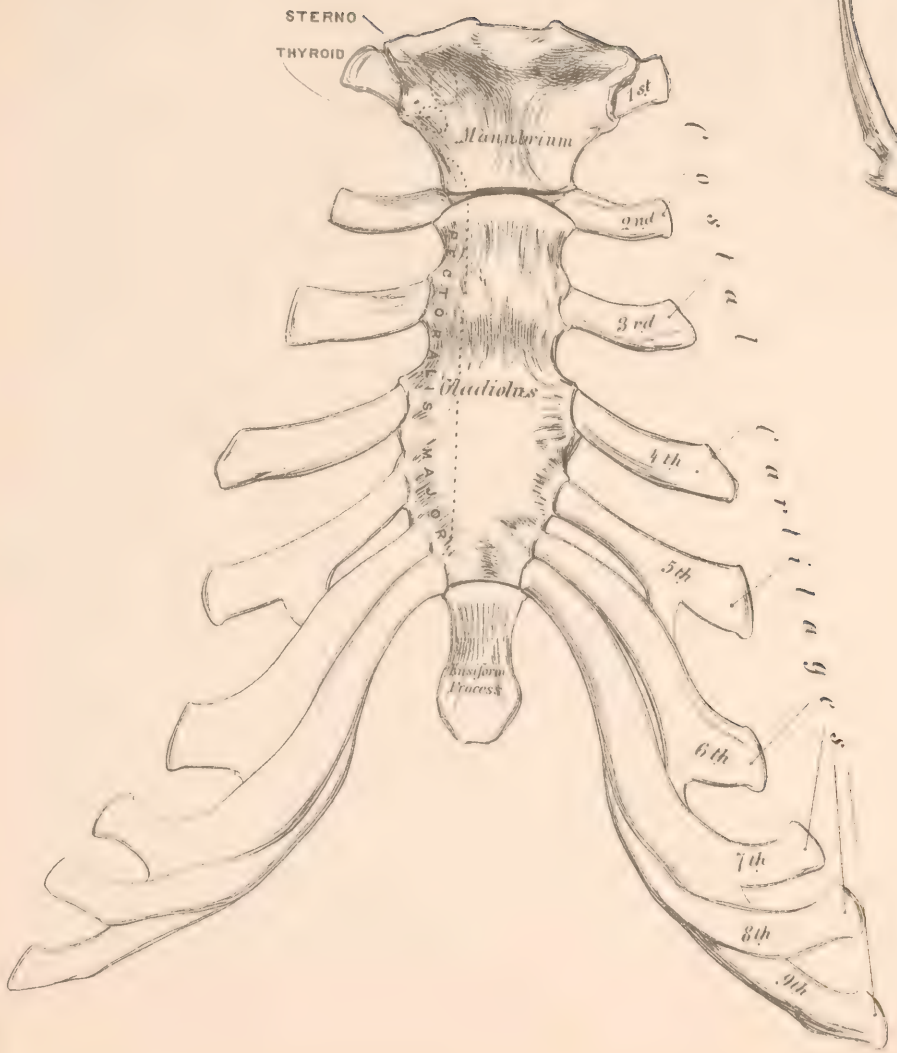
The hyoid bone gives attachment by its lower border to the thyro-hyoid membrane; by the tip of the greater horn to the thyro-hyoid ligament; by the tip of the lesser horn to the stylo-hyoid ligament. In addition to the Genio-Hyoid and Omo-Hyoid muscles already mentioned, it gives origin to the Hyo-Glossus, Middle Constrictor, Sterno-Hyoid, Sterno-Thyroid, and Thyro-Hyoid muscles, and insertion for the Mylo-Hyoid, and Stylo-Hyoid muscles.

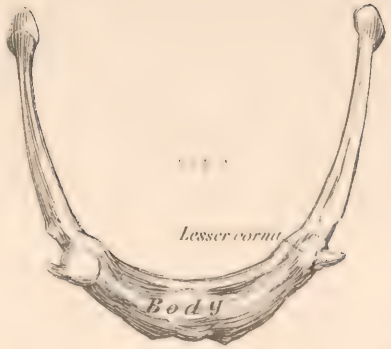
Development.—The hyoid bone arises from five centres of ossification, one for the body and one for each of the horns. The centres for the body and the greater horns appear in the ninth month of fœtal life. The centre for each of the lesser horns appears during the first year. The lesser horn remains cartilaginous until advanced life.

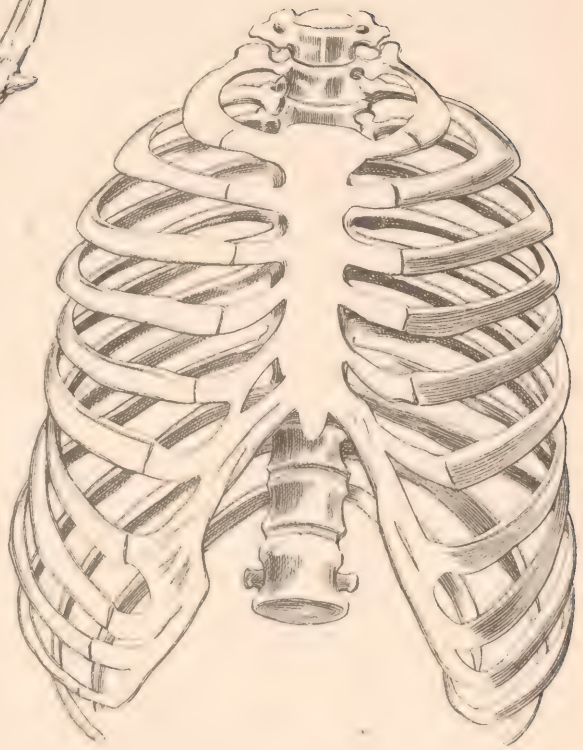
Remarks.—The greater horns of the hyoid bone are rarely exactly similar. The left lesser horn is so

EXPLANATION OF PLATE XXV.

Fig. 1. The hyoid bone, seen from above.
Fig. 2. The hyoid bone, seen from in front.
Fig. 3. The thorax.
Fig. 4. The sternum and the costal cartilages, seen from in front.


STERNO
THYROID
Manubrium
1st
2nd
3rd
Radiolus
4th
5th
6th
7th
8th
9th
Ensiform Process
RECTUS ABDOMINIS MAJOR


Lesser cornu
Body



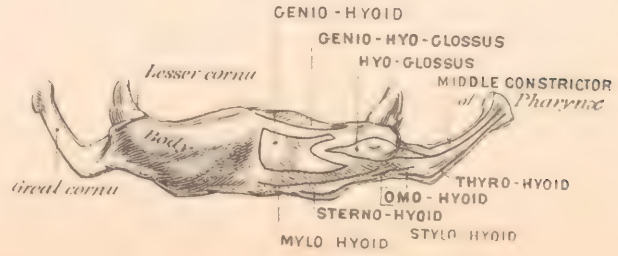

GENIO-HYOID
GENIO-HYO-GLOSSUS
HYO-GLOSSUS
MIDDLE CONSTRICTOR of Pharynx
Lesser cornu
Body
Great cornu
THYRO-HYOID
OMO-HYOID
STERNO-HYOID
STYLO HYOID
MYLO HYOID

PLATE XXV

often longer than the right that some authors have described such a condition as normal.—The hyoid bone is raised in the second portion of the act of deglutition, but falls at the end of that act. It is depressed by the action of the Sterno-Thyroid, the Thyro-Hyoid, the Omo-Hyoid, and the Sterno-Hyoid muscles. The greater cornua serve to keep the laryngo-pharynx patulous in the way that the blades of a glove-stretcher act on a finger of a glove. Directly behind the body lie the fatty fibrous tissues about the base of the epiglottis.—From the movability of the bone it is capable of being displaced by tumors. Gibbs[1] describes a tumor arising from the thyroid cartilage, producing such displacement. Retro-pharyngeal abscess at the portion of the pharynx answering to the plane of the hyoid bone has also been known to displace the cornu of the corresponding side, and to produce conspicuous deflection of the larynx from the median line.—Grasping the throat at the position of the hyoid bone may, by the forcible approximation of the greater cornua toward each other, cause either fracture or disjunction of its several parts. The bone may be also fractured in execution by hanging.

THE RIBS.

The ribs (figs. 4 and 5, Plate XXVI.; fig. 3, Plate XXV.) are those curved flat bones extending from the spine to the costal cartilages. They are twelve in number, and form a series of narrow arches which make up the lateral, the posterior, and in part the anterior, boundaries of the thorax. These arches are either prolonged by the costal cartilages to the sternum, when the ribs entering into them are called the *true* or *sternal ribs*, or they fail to join the sternum, when the ribs entering into them are called the *false* or *asternal ribs*. The true ribs are those included between the first and the seventh; while the false ribs make up the remaining five. Of the latter the eighth, the ninth, and the tenth are connected by their costal cartilages, and are held to one another as well as to the cartilage of the seventh rib. The eleventh and twelfth ribs are without fixation, and are from this circumstance known as *the floating ribs*. At times the tenth costal cartilage remains unattached to the ninth, when the number of floating ribs is three.

The classification of the ribs into the true and the false, and the restriction of the last two ribs to a separate group, are in some respects unsatisfactory. In a proper sense all the ribs are true ribs, since they vary only in the single feature of the degree of fixation of the anterior ends. Sibson[1] very properly says that it is in the dead body only that the "floating ribs" can be said to float; for in the living body they are steadied by powerful respiratory muscles. While the task of criticizing the nomenclature of the ribs is an easy one, attempts to improve upon the nomenclature have not been successful. Sibson[2] proposes the term *diaphragmatic ribs* to include the last four, since these are moved actively by the Diaphragm, the other ribs being termed by him the *thoracic*. Why all the ribs are not thoracic is not made clear by this arrangement, nor is it reasonable to omit the sixth and seventh from the diaphragmatic ribs.

Since the first six ribs present convex lower borders, give origin to the Pectoralis Major muscle (an elevator of the ribs), and move upward in inspiration; and since the last six ribs present concave lower borders, give origin to the Diaphragm (a depressor of the ribs), and move downward in inspiration, no objection can be urged to the use of the term "*upper ribs*" to designate the former group, or to the use of the term "*lower ribs*" to designate the latter. For clinical purposes this classification is all that is needed, and has at least the advantage of simplicity. At the same time it is convenient to retain the terms "true, false, and floating ribs," since they are separated from one another by trenchant and easily remembered characters.

The ribs increase in size from the first to the eighth, and decrease from the ninth to the twelfth. Each rib presents for examination a head, or vertebral extremity, a sternal or anterior extremity, a neck, a tubercle, a body, and an upper and a lower border. In addition, the majority of the ribs present an angle, and three articular facets; of the latter, two belong to the head, and one to the tubercle.

The *head* or *vertebral extremity* is furnished with an articular surface, which, in all the ribs excepting the first, eleventh, and twelfth, yields two facets, the lower of which is the larger. A faint ridge (*crista capituli*) separates the facets for the attachment of the interarticular ligament. The head of each of the ribs, as above limited, articulates with a pair of vertebræ as follows: first, with the body of the vertebra corresponding in number to that of the rib; and, secondly, with the body of the vertebra directly above it. The portion of the bone lying between the head and the tubercle is called the *neck*.—The neck is best developed

[1] Diseases of the Throat, 277.

[1] Medical Anatomy, 1869, col. 62.

[2] L. c., 1869, col. 62.

in the upper ribs, and is almost entirely absent in the eleventh and the twelfth. It is a flattened or irregularly prismatic process; smooth within and roughened without for the attachment of the middle costo-transverse ligament. Its upper border is slightly elevated from the seventh to the tenth ribs to give attachment to the anterior costo-transverse ligament.—The *tubercle* lies at the junction of the neck with the shaft. An *articular facet* is here seen which looks downward and outward to articulate with the transverse process of the vertebra to which the rib belongs. To the outer side and above the facet is a rough eminence for attachment of the posterior costo-transverse ligament.—The *body* of the rib is that portion lying between the tubercle and the sternal extremity. It is smooth on its inner side, but roughened on its outer, for the attachments of muscles, chief among which are slips of origin of the Serratus Magnus. Its *upper border* is thin and compressed in the first, the second, the eleventh, and the twelfth ribs, but rounded for the remaining ones. In all, the upper border presents a roughened surface for the attachment of the Intercostal muscles. The *lower border* is grooved (see Intercostal Muscles) from about the angle to near the anterior extremity for the reception of the intercostal vessels and nerve. The upper edge of the *groove* gives origin to the Internal Intercostal muscle; the lower edge, which is slightly produced, gives origin to the External Intercostal muscle.—The *angle* is that portion of the rib in connection with the insertion of slips of the Sacro-Lumbalis muscle. It determines the limits of the medio-dorsal aspect of the thorax, *i. e.*, the space limited by points at which the ribs are abruptly directed forward. Almost absent on the first rib, the angle is slightly developed on the second, third, and fourth ribs; it increases in size until the eleventh is attained, beyond which it again decreases, and is entirely absent on the twelfth.—The *sternal* extremity of the rib is broader than the body, excepting from the ninth to the twelfth ribs, where it is smaller. The borders of this extremity are obtuse; the terminal surface is concave for the corresponding costal cartilage. The sternal end of the costal curve has been called, on perhaps insufficient grounds, *the anterior angle*.[1]

The Twist of the Rib.—The general form of the rib, while arched outward and forward, is curved downward, so that the sternal end is lower than the vertebral. As the ribs increase in length from above downward the tendency of the inner surface *near the vertebral end* to be inclined downward and inward is decided. In common with this the surface about the *middle of the body* of the bone is inclined downward and outward. The gradual change from one to the other inclination, conjoined with the tendency constantly present of the sternal end of the bone to assume a position below the plane of the vertebra to which it belongs—a tendency best seen in the ribs from the fifth to the ninth—gives a spiral shape to the bone which has been described as the *twist of the rib*. This shape is more evident in the isolated bone than in articulation.

Peculiar Ribs.—The foregoing description is applicable to a rib situated between the third and the tenth. It would not apply to the others, for the following considerations:—

The *first rib* is placed more horizontally than the other ribs, and yields a shorter curve. Its outer surface looks upward, and its inner surface looks downward. The head bears a single articular facet, and articulates with the first dorsal vertebra alone. Its upper surface is marked by a faint ridge which terminates in a tubercle upon its upper border for the insertion of the Scalenus Anticus muscle. In front of this is a broad shallow *groove* for the subclavian vein; behind it lies a second deeper *groove* for the subclavian artery. To the outer side of the groove for the subclavian artery is a rough surface for insertion of the Scalenus Medius muscle. The tubercle of the first rib is the largest of any of the ribs, and is firmly sup-

[1] Cruveilhier, Anatomy, l. c., Birkett, Trans. Path. Soc. of Lond., 1853, 105.

EXPLANATION OF PLATE XXVI.

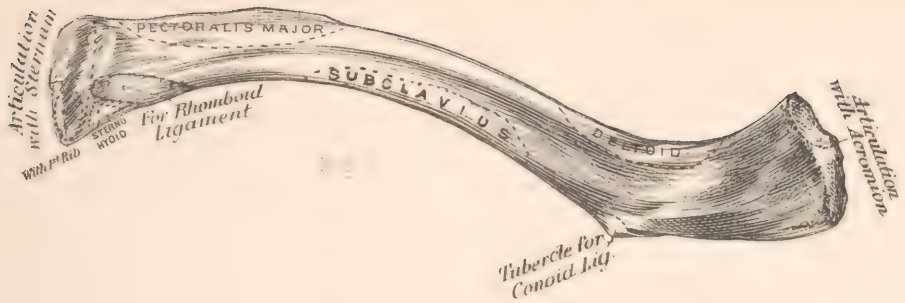
Fig. 1. The clavicle, seen from beneath.

Fig. 2. The clavicle, seen from behind. The nutritious foramen lies directly above the letters "Fig. 2."

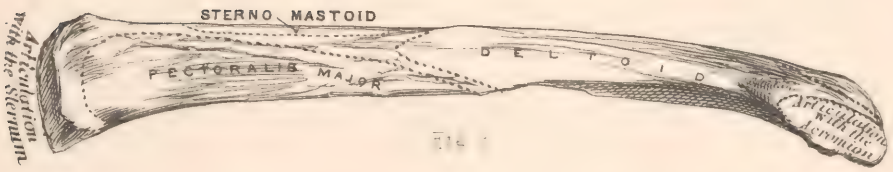
Fig. 3. The clavicle, seen from in front.
For "STERNO-MASTOID" read "STERNO-CLEIDO-MASTOID."

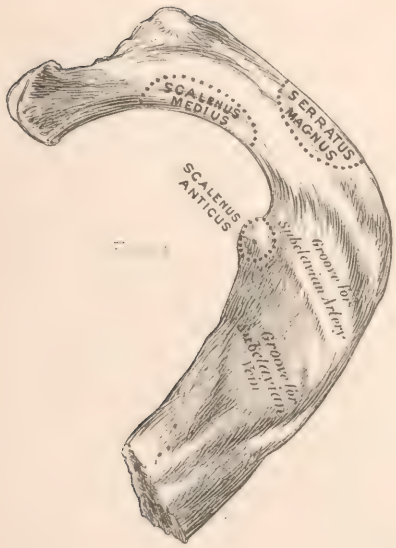
Fig. 4. The first rib, seen from above.

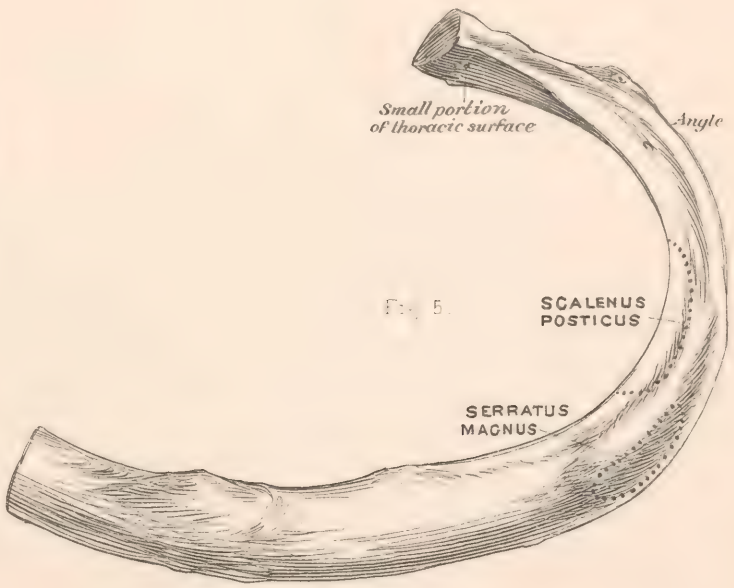
Fig. 5. The second rib, seen from above.











T. Sinclair & Son, Lith

ported by the transverse process of the first dorsal vertebra. The angle is almost absent, and no groove exists for the intercostal vessels and nerve. The sternal extremity is thicker than in any of the true ribs.

The *second rib* agrees with the first in being more horizontal than the other ribs. Its head presents a faint interarticular ridge. It is marked upon its outer surface by a large rough surface for attachment of the Serratus Magnus muscle.

The *eleventh* and *twelfth* ribs yield larger curves than do the other ribs. Their inner surfaces opposite the neck are more inclined, while, as already seen, the anterior extremities are narrowed.

In addition to the above characters of the ribs the following may be considered with advantage in identifying isolated ribs or fragments:—

The facet of articulation with the transverse process of the vertebra is in the first rib carried upon the end of a short process, which is directed slightly downward, so that the end of the process is best seen upon the lower surface of the rib. The ribs from the first to the sixth seen in articulation from the interior of the thorax present at the point answering to the neck a vertical surface, and exhibit from the upper borders of the smooth surfaces entering into the pulmonary sinus a slight crest for the anterior costo-transverse ligament. The ribs from the seventh to the twelfth present from within the thorax a slightly inclined surface at about the neck, and each bears a sharp crest at the upper border.

Structure.—The ribs are cancellous throughout (being least so at the angle), with firm lateral walls.

Development.—Each rib arises from a single centre of ossification for the body which appears as early as the eighth week, and from two small accessory centres, one appearing in the head and the other in the tubercle. The rib is completed at about the twenty-fifth year.

Remarks.—Deformity of the rib may be either congenital or acquired. Dr. Robert Adams has recorded[1] an instance of congenital deformity of the first pair of ribs. The left rib was two inches long and straight, and presented a free projecting, somewhat flattened extremity, which was joined to the second rib by a process ascending from the latter. The left subclavian artery ran in front of the distal extremity of the deformed rib as above described, and was supported by the bony elevation of the second rib. The right first rib was shortened and malformed, and supported the right subclavian artery.—A forked rib is one which sends off a process either above or below the main costal axis. It may end in an intercostal space, or, advancing forward, may be joined by an intercostal cartilage.—The sternal ends of the ribs are apt to be deformed in rickets.—Dislocation of the rib is a rare lesion.[1]—The ribs are among the most vascular of the bones, and are hence liable to caries and inflammation.—The angles of some of the ribs are so roughened externally that a careless observer may mistake such appearances for the effects of old fractures. The inner aspect in such specimens is always smooth, and can thus be distinguished from ribs that have been fractured. The last cervical (see p. 114) and the first lumbar vertebra rarely bear rib-like processes. The last-named rib is the more frequent. The twelfth rib may be absent or smaller than usual.—The ribs that are most exposed are those included between the fourth and the tenth, and these therefore suffer most from direct violence. In fracture the bone most frequently gives way at the angle or near the sternal end.

[1] Dublin Path. Soc. Trans., 1839, quoted in Med.-Chir. Trans., lii. 288.

THE COSTAL CARTILAGES.

Attached to the sternal ends of the ribs are twelve cartilages which, from their resemblance to the ribs, have received the names of the *costal cartilages* (fig. 4, Plate XXV.). In the upper ribs these cartilages lie between the sternal ends of the ribs and the side of the sternum; in the lower ribs they either lie between the sternal ends of the ribs and the borders of adjacent ribs, or, as in the last two, they serve as tips simply to their respective bones. The cartilages of the false ribs aid in defining the inferior margin of the thorax anteriorly. The ends of each cartilage are convex, and are secured in corresponding depressions on the ribs and the sternum. The union of the cartilage with the corresponding rib is in all instances without articulation; but the union of the cartilage with the sternum is diarthrodic, excepting that of the first rib.

Respecting the shape of the costal cartilage it may be said that the costal portion of each cartilage is in the line of the sternal end of the rib to which it belongs. In the ribs from the first to the fourth, and in

[1] Buttet, Mém. de Chirurg., v. 1784, 593.

the eleventh and the twelfth, the entire cartilage is thus placed; but in the remaining ribs the costo-axial portion is less than one-half of the entire length of the cartilage. The remaining or sternal portion ascends at an angle to the costal, either to join the sternum or the adjacent cartilages. The degree of ascent in each cartilage bears an exact relation to the downward inclination of the rib to which it belongs. The sternal end is narrowed to a greater or less degree in all the costal cartilages excepting the first.

The movements of the upper costal cartilages are more or less limited, if indeed they are not entirely absent at the region of the first rib. The movements of the lower ribs, on the other hand, are very free; they expand the base of the thorax in inspiration. Hence the costal cartilages may be said to increase the basal measurement of the thorax while aiding the ribs in maintaining the elasticity of the thoracic walls. Owing to ossification of the cartilages, this elasticity diminishes in adult life, especially at the region of the upper ribs. In old age the costal cartilages are almost invariably ossified. In adult life they may be fractured.

THE STERNUM.

The sternum, or the breast bone (fig. 4, Plate XXV.), is a large flat bone placed at the anterior part of the thorax, and is held in position by the ribs. It assumes a slanting position downward and forward, so that its anterior surface looks slightly upward, and its posterior looks downward and backward. Its upper border is thus nearer the vertebral column than the lower, and answers in position to about the level of the second dorsal vertebra. The sternum is from seven to eight inches long, by one-and-a-half to two inches wide, and is six lines thick at its lower part. It is broader above than below, and is marked upon the sides along nearly its entire length by concave depressions for union with the costal cartilages.

The sternum bears a rude resemblance to an ancient Roman sword, and its several portions have been named in consequence the *manubrium* (handle, presternum), the *gladiolus* (body, blade, mesosternum), and the *ensiform process* or *cartilage* (xyphoid cartilage, tip, metasternum). The line of junction between the manubrium and the gladiolus forms a distinct transverse ridge upon both the anterior and the posterior aspect of the bone. The former is often visible in the living subject.

The *manubrium* is the stoutest and thickest portion of the bone. It is broad above, somewhat contracted below. It is a little less than half as long as the gladiolus, and serves for articulation with the first pair of ribs and the clavicles. Its upper margin is thick and rounded, and is transversely concave to form a semilunar depression—the *inter-clavicular notch* (fourchette)—which is covered by the inter-clavicular ligament, and is deepened in life by the median ends of the clavicles. Upon either side of the notch are the articular, saddle-shaped surfaces for the last-named bones. They are directed downward and outward, are concave from without inward, while convex from before backward. The lower margin of the manubrium is nearly flat for articulation with the gladiolus. The sides are marked above by the simple depression for the first costal cartilage, and below by the half facet entering into the costo-sternal articulation of the second rib. The first-named joins the outer border of the clavicular articular surface, and is inclined obliquely downward. The manubrium has the following muscular attachments: the Sterno-Cleido-Mastoideus, the Sterno-Hyoid, and the Sterno-Thyroid muscles; the last two appearing upon the posterior surface.[1]

The *gladiolus* is somewhat egg-shaped, being slightly broader below than above. Its lateral margins are marked by double-faceted depressions for the costal cartilages, in such order that the second rib joins the manubrio-gladiolar junction, and the seventh rib joins the gladiolus and the ensiform cartilage. The remaining costal cartilages are separated by semilunar depressions, which toward the lower end of the bone are nearly if not quite contiguous. The anterior surface is marked by three transverse lines, which indicate the union of the four pieces of which this portion of the sternum originally consists. An opening (sternal foramen) indicating a defect of development between the third and the fourth pieces is occasionally found. The gladiolus gives attachment to the Pectoralis Major in front and to the Triangularis Sterni behind.

The *ensiform process* or *cartilage* is a thin spatula-like process having a variable length of from one-half inch to one-and-a-half inches. It is depressed below the level of the lower extremity of the gladiolus, so that when the integument covering it is in position a pit is demonstrable, consisting of the so-called *scrobiculus cordis*, or pit of the stomach. It is embraced by the linea alba. The anterior surface gives attachment to the costo-xyphoid ligaments; the posterior surface to

[1] By a mechanical error the attachment of the last-named muscle is represented in the figure upon the *anterior* surface.

the Diaphragm and the Triangularis Sterni muscle. Its borders are attached to the aponeuroses of the abdominal muscles.—The ensiform cartilage is the most variable portion of the sternum. Instead of being spatula-like, it may be rounded, or forked. It may be deflected from the median line, or even turned directly backward. It is sometimes furnished with foramina.—According to Sibson,[1] the basal half inch of the ensiform cartilage receives at its side the fibres of the Diaphragm that appear in the notch between the cartilage and the seventh rib. The pleura lines these fibres posteriorly.

Structure.—The sternum is composed of small, very vascular cancelli, inclosed between the anterior and the posterior walls.

Articulations.—The sternum articulates with the clavicles and the costal cartilages from the first to the seventh inclusive.

Development.—The first centre of development appears in the manubrium at the fifth or the sixth month of fœtal life, and is usually single. The upper portion of the gladiolus forms a distinct segment, and arises from a single centre at the seventh month. For the remaining three segments the centres ordinarily appear in pairs within the first year. The ensiform process does not ossify until the sixth year. The gladiolus is complete about the twenty-fifth year.

The sternum rarely or never completely ossifies, except in old age. Thus the manubrium and the gladiolus are united by cartilage. The remaining portions, however, coalesce. The junction between the ensiform process and the gladiolus is perfected at about middle life, and the different portions of the gladiolus from the twentieth to the fortieth year.

Congenital defects of the sternum ordinarily have their origin in the failure of the bi-lateral centres of the gladiolus to unite in whole or in part.

Remarks.—The sternum from its cancellated structure is a relatively vascular bone, and responds to diseased action very much after the manner of spongy bone elsewhere. It is, as a consequence, a frequent site of caries, particularly in the negro; it is the locality to which the pains of constitutional syphilis are commonly referred. It yields readily to pressure, as from an aortic aneurism, and can be perforated by sharp cutting instruments.—The sternum is subject to considerable variation in form. Thus, the two clavicular facets may not be of exactly the same height; a supplemental pair of costal cartilages are rarely appended to the base of the ensiform cartilage. As already mentioned, one or more rounded openings, resulting from defective ossification, are occasionally seen in the gladiolus. Instances have been collected of punctured wounds received through such spaces—while mediastinal abscesses have opened through them.[1] The transverse line between the manubrium and the gladiolus is often so pronounced as to resemble an old fracture.—The ensiform cartilage, when deformed either by growth or by vicious position after injury, may by its backward pressure excite irritation.[2]

The sternum is covered by fibrous tissue on all its surfaces, recalling in both position and use the periosteum. The anterior fibrous layer is composed of fibres which cross one another in every direction, and which are closely adherent to the surface of the bone and the cartilages. The posterior layer is composed chiefly of longitudinal bands of white fibrous tissue, which are but slightly adherent to the bones and the costo-sternal articulations.[3] It is much stouter than the anterior, and in dislocation of the parts of the sternum on each other may be stripped from the bone. In the now nearly obsolete operation of trephining the sternum, this membrane is an obstacle to the easy removal of the circle of bone.[4]

The joint between the manubrium and the gladiolus, according to Maisonneuve,[5] is either fibrous or diarthrodial; it is fibrous in character in about twenty-five per cent. of cases, and diarthrodial in seventy-five per cent. The joint is rarely obliterated.[6]

When the diarthrodial joint exists, the layer of fibro-cartilage belonging to the gladiolus is continued on each side without interruption to the facet destined for the cartilage of the second rib, whilst the layer belonging to the manubrium adheres to the upper border of the second costal cartilage. The latter slip is separated as a rule from the manubrium by a synovial membrane. It is absent in about three per cent. of specimens. It follows upon this arrangement, according to Maisonneuve, that the second rib is much

[1] Medical Anatomy, l. c.

[1] Cruveilhier, Anatomy of the Human Body (Am. ed.), 1844, 65.

[2] Blandin, Topograph. Anat., Doane edition, 1834, 163.

[3] Jno. H. Brinton, Am. Journ. Med. Sci., 1867, 39.

[4] Hyrtl, Topograph. Anat., i. 548.

[5] Archives Générales de Médecine, iii. Série, xiv. 1842.

[6] Brinton, Jno. H., l. c. W. Rivington, Med.-Chir. Trans., lvii., 1874, 112, found one-half per cent. to be fibrous, one-third to be diarthrodial, and the remainder to be intermediate between the two already named, or obliterated by ossification. The diarthrodial form is more commonly met with in males than in females.

more strongly attached to the manubrium than to the gladiolus. This explains the fact that in luxation of the manubrium or the gladiolus the latter always abandons the cartilage of the second rib, while the former remains constantly united to it.

Episternal bones in the form of small sub-rounded nodules attached to the upper margin of the manubrium are rarely seen.[1] They are situated on either side of the interclavicular notch, and are homologous with the larger bones of the same name in the monotreme mammals. In man they are of use in giving increased support to the thoracic ends of the clavicles.—A tumor of the sternum simulating aneurism has been described by Ollivier.[2]—The projection on the anterior surface of the bone at the union between the manubrium and the gladiolus, when pronounced, retains the mediæval name of the *angulus Ludovici*. It indicates recession of the first pair of ribs, and is often found associated with other tubercular tendencies.—The skin over the sternum retracts to a great degree after incision. More than usual care should as a result be taken in making incisions in this region of the body.[3]—For differences in the measurements of the sternum in the male and the female, see page 102.

The sternum being suspended to the costal cartilages follows the movements of respiration. The lower portion is pushed forward in inspiration, while the bone is raised. It follows that the relations of the sternum to the fixed parts will vary. Subject to slight modification it may be said that the upper margin of the sternum answers to the second dorsal vertebra or to the second dorsal spine; the junction between the manubrium and the gladiolus is opposite the third dorsal spine, and the junction between the gladiolus and the ensiform cartilage is opposite the sixth dorsal spine.—The median line of the sternum is not parallel to the median line of the abdomen, but forms with it an angle at the ensiform cartilage which is directed to the right.[4]

THE THORAX.

The thorax is that portion of the skeleton formed by the articulation of the ribs, the costal cartilages, the sternum, and the dorsal vertebræ. In the undissected subject, the thorax is equivalent to the chest of common language, and includes the Intercostal muscles at the sides and the Diaphragm at the base. The thorax is the great respiratory cavity of the body as well as the chamber for protection to the heart, and in some degree to the great vessels, the œsophagus, and in the fœtus to the thymus gland.

The figure of the thorax is conical, compressed from before backward, and presents oblique upper and lower surfaces. It is grooved longitudinally on either side of the spinous processes at the back; it is flat, and inclined slightly forward in front, and is convex at the sides. Within, the thorax presents a general concave surface except posteriorly, where the bodies of the dorsal vertebræ project forward. Its greatest circumference is about its middle or a little below, where its average measurement is twenty-five inches.

The thorax presents for examination the dorsal vertebræ, the ribs, the costal cartilages, and the sternum (which have been described), as well as the superior and inferior apertures, and the intercostal spaces.

The *superior thoracic aperture* is bounded behind by the body of the first or second dorsal vertebra, at the sides by the first pair of ribs and the costal cartilages, and in front by the upper border of the sternum. It is kidney-shaped, its antero-posterior (sagittal) diameter being a little over two inches, while its transverse (frontal) is nearly five. It contains the œsophagus, the trachea, the apices of the lungs, the pleuræ, the subclavian arteries and veins, the carotid arteries, the internal jugular veins, the termination of the thoracic ducts, and the lymphatics and nerves.

The *inferior thoracic aperture* is of an irregular figure, owing to the absence of union of the eleventh and twelfth ribs with the other ribs or sternum. It is less fixed in its outline as compared to the superior aperture, in consequence of the larger proportion of cartilage intervening between the ends of the ribs and the sternum. It is closed by the Diaphragm in the subject, yet permitting the passage of the inferior vena cava, the aorta, the œsophagus, the main thoracic duct, and the sympathetic nerves.

The *intercostal spaces* are narrower behind than in front, and with the upper ribs they are widest at about the junction of the ribs and the costal cartilages. The spaces between the false ribs naturally lessen in width as the cartilages converge towards each other. The spaces are occupied in the subject by the Intercostal muscles, the arteries, and the nerves. The first and the second are larger than the others, but on the whole the spaces tend to increase from above downward—that between the sixth and the seventh rib being the widest at the sternal margin.

[1] Luschka, Zeit. für wissenschaft. Zool., 1852, 36; T. W. King, Guy's Hosp. Rep. v. 1840, 227.

[2] Comptes Rendus, 1868, 221.

[3] Richet, Anat. Medico-Chirurg., 545.

[4] Sibson, l. c., quoted from J. W. Conradi. Upon the Position and Size of the Thoracic Organs. Giessen, 1848, 3.

In addition to the terms *superior* and *inferior* apertures the terms *apex* and *base* are in use by clinical writers. The *apex* is vaguely defined, and may be said to answer to the upper portion of the cone-like figure of the thorax. It has also been said to accommodate the apical portions of the lungs. In consequence of the fact that the apex of the lung is not confined to the thorax, the latter determination can have but slight significance. The *base* of the thorax is of much more value. It is defined by Sibson[1] in the following language: The base extends like a girdle across the lower ribs from the end of the eighth rib in front to that of the twelfth behind, and answers to the circuit at which the pleura is reflected from the Diaphragm upon the ribs and the Intercostal muscles, and down to which the lungs can descend during the deepest possible inspiration in the living, and when distended to the full in the dead. In such a position as the one last named, the base of the thorax is almost a straight line, crossing the extremities of the four lower ribs in an oblique direction from before backward and downward.

Remarks.—The shape of the thorax and the proportion it bears to the rest of the body are subject to much variation. In the infant the thorax is relatively smaller than in the adult. In the female the upper portion of the thorax is less compressed from before backward, and is more capacious than in the male; the superior thoracic aperture is larger, and the motions between the upper ribs and the sternum and the vertebræ are more conspicuous. From these circumstances the respiratory movement in the thorax of the female is decided as compared with that of the male, and has from this circumstance been called *thoracic*. In the male the lower ribs and the abdominal walls are seen moving more freely than the upper; so that with him respiration is said to be *abdominal*.

The thorax is of necessity modified in shape by the condition of its contents. When the lungs are expanding as in *inspiration*, the ribs from the first to the sixth (upper ribs) are raised toward one another so as to narrow the intercostal spaces, the sternum ascends, and the anterior thoracic aperture assumes a nearly horizontal position. At the same time the ribs from the seventh to the twelfth (lower ribs) are depressed so as to widen their intercostal spaces, and the inferior thoracic aperture is increased in size; the twelfth rib remaining nearly stationary. When the lungs are contracted as in *expiration* the reverse of the movement described takes place. The upper ribs are far apart, and the remaining ribs are elevated and approximated at the side of the chest.

In emphysema the characteristics of inspiration with bulging intercostal spaces, and in phthisis those of expiration with depressed intercostal spaces, are maintained and exaggerated. In chronic asthma a peculiar cylindroid form of thorax is detected, which has received the name of the "barrel chest."

The respiratory movements may, indeed, be said to determine the shape of the thorax. Even in the artificial skeleton the disposition of the ribs from the first to the sixth to present convex lower borders, and that of the ribs from the sixth to the tenth to present concave lower borders, is evident. By this character the ribs that *ascend* in respiration can be distinguished from those ribs that *descend* in respiration, the latter being least marked in the case of the eleventh and the twelfth.

A careful inspection of the interior of the thorax in the skeleton is useful. The first and second ribs directly overlie the thoracic chamber, forming its roof; the remaining ribs lie at the sides. It is evident that the first-named ribs will yield a percussion note answering more exactly to the resonance of the entire thoracic space than will one elicited from the ribs either at the sides or at the back.—The projection of the line of bodies of the dorsal vertebræ forward, and the curvature of the ribs, give to the transverse sections of the thorax a kidney-shape. The vertebral column answers to the hilus of this figure, and the deep symmetrical curves on either side to the surface above and below the hilus. These deep curves lying between the sides of the vertebræ and the sides of the thorax correspond to the posterior thoracic surface, and may receive the name of the *pulmonary sinuses*, since they lodge the convex posterior surfaces of the lungs.

The form of the thorax is in great measure concealed in the undissected subject. The clavicles and the muscles attached to it obscure the outline of the first and second ribs. The scapula, when the arms are at rest, covers in and conceals the dorsal surface from the second to the eighth or ninth ribs. In front, at the back, and at the sides, muscular masses protect the parietes as with pads or cushions, and remove many of the costal surfaces from observation and the touch. It is well to remember that even in very muscular or fleshy individuals the following points can always be made out, no mention of the sternum and the beginnings of the costal cartilages being

[1] Medical Anatomy, col. 37.

thought necessary. The anterior border of the Pectoralis Major answers to the line of the fifth rib. The first visible digitation of the Serratus Magnus is attached to the sixth rib; the second digitation to the seventh rib. The hand of the subject or model being placed upon the head exposes the *axilla*, which is defined by the Pectoralis Major and Pectoralis Minor in front, and by the Latissimus Dorsi, Teres Major, and Subscapular muscles behind: the Serratus Magnus forms the *floor of the axilla*, which corresponds to the space from the second to the fifth ribs. In this space the lung-sounds can be heard with greater ease than at any other part of the chest, and they should here be sought for in all careful examinations of the conditions of the apex.—Richet[1] states that abscess of the axilla can cause irritation and thickening of the adjacent pleura by direct transmission through the thoracic parietes. Holden[2] suggests that the lines of the anterior and the posterior walls of the axilla produced down along the sides of the thorax should receive the name of the *axillary lines*.—The *nipple* overlies the fourth intercostal space, the fourth or even the fifth rib. It varies in position according to the state of the thorax. In emphysema the nipple, if it remains stationary while the upper ribs ascend, would answer to the fifth, and in extreme cases to the eighth. On the other hand, in shallow chests with depressed ribs, as seen in phthisis, the nipple may answer to the fourth.—The costal cartilage of the seventh rib lies at the junction of the base of the ensiform cartilage with the gladiolus. This position can be readily determined on the subject through the integument, and an easy method is thus presented of fixing the anterior border of the inferior thoracic aperture.—The positions of the floating ribs can always be recognized by the touch.

If a tape-line whose initial end lies over the sternal end of the first rib is drawn transversely across the front of the thorax, and thence to the spines of the vertebral column, the terminal end will be found to rest upon the vertebral end of the fifth rib. On such a basis Luschka has elaborated, as in the following table, a series of lines for all the ribs:—

TABLE OF RELATIONS BETWEEN THE ANTERIOR AND POSTERIOR SURFACES OF THE THORAX.

STERNAL END.	POSTERIOR EQUIVALENT.
The Sternal end of the first rib is on the same line as	the Vertebral end of the fifth rib
" " " second "	" " " seventh "
" " " third "	" " " eighth "
" " " fourth "	" " " ninth "
" " " fifth "	" " " tenth "
" " " sixth "	Middle of the vertebral and of the space between the tenth and eleventh ribs
" " " seventh "	Vertebral end of the eleventh rib
" " " eighth "	Beginning of the transverse process of the first lumbar vertebra
" " " ninth "	Near the body of the second lumbar vertebra
" " " tenth "	Near the body of the third "
" " " eleventh "	" " " "
" " " twelfth "	" " " "

From what has been said in connection with the subject of the respiratory movements of the thorax, it is evident that some variation will exist in these lines. In the thorax prepared in the form of inspiration the lines for the upper six ribs would lie somewhat above the level of the vertebral equivalents given in the table; in like manner, in the thorax prepared in the form of expiration, the lines for the lower ribs would be a little below.

For the relations between the liver, the stomach, and the spleen and the base of the thorax, see the account of those organs.

[1] Anat. Medico-Chirurg., 877.

[2] Landmarks, 68.

THE BONES OF THE UPPER EXTREMITY.

The bones of the upper extremity are those of the shoulder, the arm, the forearm, and the hand; they include the clavicle, the scapula, the humerus, the ulna, the radius, the carpal bones, the metacarpal bones, and the phalanges.

THE CLAVICLE.

The clavicle, or the collar bone (figs. 1, 2, 3, Plate XXVI.), is the medium by which the superior extremity is connected to the trunk. It is placed superficially, so that its superior and anterior surfaces can

be defined in the undissected subject between the thorax and the scapula, receiving above the insertions of muscles descending from the neck, and affording surfaces of origin to those ascending from the sides of the chest. The clavicle is inclined from the sternum and the first costal cartilage (see fig. 3, Plate XXXVII.) a little diagonally outward and backward, and at the thoracic two-thirds is cylindroid, while at the scapular third it is flat, thin, and irregular.

Seen from above, the bone is shaped like an italic letter *f*, placed horizontally; the initial right-hand curve is the *thoracic end*, the main stroke of the letter is the cylindrical *shaft* or *body;* the terminal curve is the *scapular* or *acromial end.* At the junction of the thoracic end with the shaft, on the under surface, the *impression for the costo-clavicular ligament* is seen; at the junction of the body with the scapular portion lies the *conoid tubercle.*

The *body* of the clavicle extends from the outer margin of the impression for the costo-clavicular ligament to the conoid tubercle. It is slightly narrowed from before backward to give origin to the clavicular fibres of the Pectoralis Major muscle; it is convex anteriorly and concave posteriorly. The curves of the body are continuous with those of the thoracic, but are abruptly separated from those of the scapular end. The orifice of a *nutritious canal* directed laterally is seen on the posterior surface. Stretching across the under surface of the body from the conoid tubercle in front to the posterior and inferior border is an oblique line which limits the surface of origin of the Pectoralis Major muscle inferiorly. Near the oblique line is the narrow *depression* for the Subclavian muscle.

The *thoracic end* of the clavicle is nearly square, the anterior and the posterior surfaces remaining as in the body, while the superior and inferior are broader. The superior smooth surface receives at its posterior border the insertion of the clavicular portion of the Sterno-Cleido-Mastoideus muscle. The anterior surface presents a ridge for the fibres of the Pectoralis Major, while the inferior surface toward its anterior aspect is roughened, as already mentioned, by the impression for the costo-clavicular ligament. The posterior surface is smooth. The *articular surface* is of a triangular or subrounded figure, the broadest portion being directed upward and forward, while the narrowest is downward and backward. The articular surface is depressed in the centre, and all the borders excepting the superior are rounded, and appear more or less upon the sides (fig. 2, Plate XXVI.). The antero-inferior lateral facet, as contrasted with the others, is limited abruptly by a sharply projecting lip. The lower end is the least liable of any part of the thoracic portion to be invaded by diseased action. In the macerated bone the articular surface is roughened and irregular, but in the subject it is smooth and saddle-shaped.

The *scapular* or *acromial* end of the clavicle extends from the conoid tubercle to the end of the bone. It is broad and flat, thicker behind than in front, sharply concave anteriorly and abruptly convex posteriorly. The anterior edge of the upper surface gives origin to the Deltoid muscle by a deep lunated impression. Near the posterior border a faint ridge indicates the insertion of the clavicular fibres of the Trapezius. The under surface from the conoid tubercle forward and outward is irregularly ridged (oblique line) for the attachment of the coraco-clavicular ligament. The oval or rounded scapular (acromial) articular surface does not occupy the entire end; it joins the anterior edge of the bone, and looks obliquely downward and outward.

Structure.—The clavicle resembles a long bone in presenting a shaft with walls and spongy extremities. The shaft or body is in great part occupied by a number of lamellæ, beginning and continuous with the thin anterior wall, and extending across the body near to the enormously thick posterior wall. The latter is thicker in the middle than towards the ends of the body, and is gradually lost within the thoracic and the scapular ends. At the junction of the body with the scapular end, the anterior is of equal thickness with the posterior wall, and the interior of the bone is filled with coarse, stout laminæ. It is probable that the disposition of the parts last named explains the great relative frequency of fracture of the clavicle at the junction of the outer with the middle third of the bone as compared with fracture at any other portion. In the thoracic third the cancelli are small, and give increased compactness to the bone at this part. The uppermost cancelli, being here the weakest, are often exposed and disintegrated in cabinet specimens. In the scapular end the most compact tissue lies anteriorly in the line of the facet of articulation; posteriorly the cancelli resemble in structure and behavior the upper portion of the thoracic end already described.

Development.—The clavicle arises from cartilage[1] by two centres of development: one for the main

[1] The bone is generally described as arising from fibrous tissue. Gegenbaur (*infra*) is the authority for the contrary statement.

portion of the bone which appears about the sixth week, and one for the sternal end (pre-coracoid of Kitchen Parker) which appears after the manner of an epiphysis at about the eighteenth year. The epiphysis unites with the shaft at the twenty-fifth year.

The clavicle is thought to be homologous with an intermuscular space or septum (such as the linea transversa of the Rectus Abdominalis) which lies between the Trapezius and the Sterno-Cleido-Mastoid muscles on the one hand, and the Deltoid on the other. In animals without a clavicle, the Trapezius and the Deltoid muscles are continuous, as in the seal and the carnivora generally. In the bear a transverse fibrous inscription alone separates the Deltoid from the cranial fibres of the Trapezius. In the cat, the raccoon, and allied animals a small movable bone without osseous attachment of any kind intervenes between the two muscles.

Remarks.—The clavicle is exceedingly variable in form. In muscular individuals the curves are pronounced, the thoracic articular surface is produced downward, and the facet answering to the upper surface of the first rib is large.—The impression of the claviculo-costal ligament is either on the level of the bone or raised slightly from it. This impression is sufficiently deep in the bone just prior to the union of the median epiphysis to lead observers to mistake it for an effect of diseased action.—The lower border of the impression for the Deltoid sometimes projects as a ragged spine; the posterior border of the acromial end is rarely produced to the level of the plane of the facet, thereby greatly increasing the width of the bone at that place.—In the female the clavicle is straighter than in the male, and the muscular and ligamentous impressions are but faintly marked. The ridge for the coraco-clavicular ligament is sometimes lumpish.—The clavicle occasionally exhibits a foramen at the upper border of the body for the transit of the supra-clavicular nerve.—E. H. Bennett[1] records four examples of variation in the scapular end of the left clavicle, consisting in the extension of the posterior border of the bone to or beyond the level of the plane of the facet, and in the exhibition of a secondary facet which articulates with the spine of the scapula by a diarthrodial joint. In two of the instances the scapula at the acromion was deformed. The region of the scapular facet may exhibit in connection with the last-named variation the results of mal-nutrition, inflammation and erosion, as occurred in two bones that have come under the writer's notice. In such clavicles the enlarged, thickened, and deformed parts are irregular in form, and bear a strong resemblance to formations of old callus, and may be thus mistaken for the effects of fracture. It is well to observe that these appearances are not seen *crossing* the bone, but are confined to the facet and the parts extending thence to the anterior margin of the scapular end.—For variations in the lengths of the clavicles, see p. 102.—C. Gegenbaur[1] describes from the living subject four cases of symmetrical absence of the acromial end of the clavicle, occurring in a mother and her three children. In each case a conspicuous depression existed between the shoulder and the front of the chest, at the bottom of which the subclavian artery could be felt beating. *The motions of the scapula appeared to le unimpaired.*

The motions of the clavicles are determined by the movements of the chest and of the superior extremity. Since the union between the clavicle and the scapula is nearly fixed, that between the clavicle and the sternum and the first rib permits of free motion, and causes the thoracic end of the bone to act as a fulcrum to the scapula, and through the latter to the entire upper extremity. The attachment of the clavicle to the first rib by the antero-inferior lateral facet serves, according to G. Hermann Meyer,[2] to transfer the weight of the superior extremity (as instanced in carrying a heavy body on the shoulder or in the hand) from the arm and the clavicle to the trunk—the vertebral column eventually bearing such strain as is diffused to it through the manubrium and the first pair of ribs.

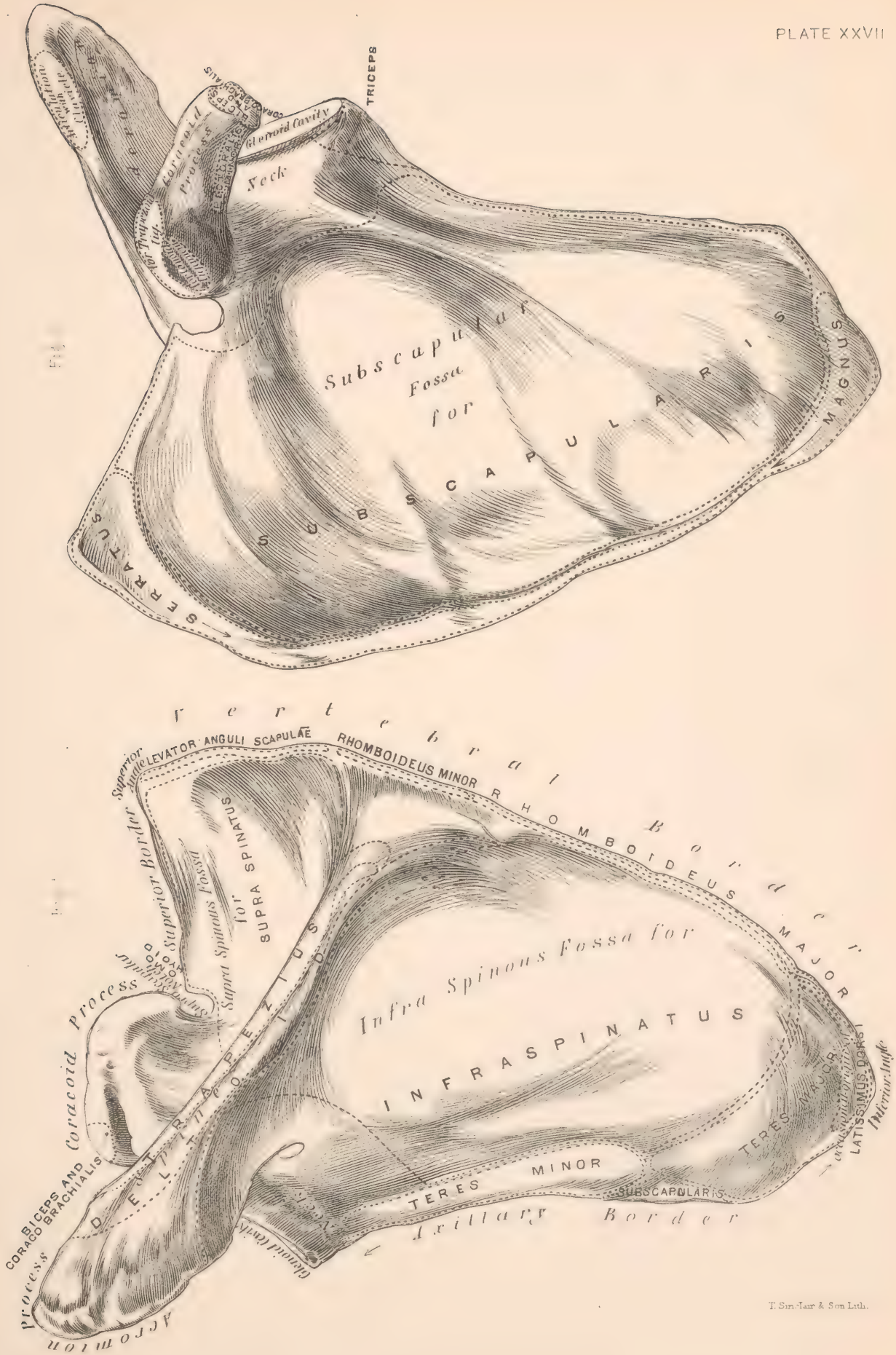
The bone when in the position of rest is on the same level as the spine of the scapula. In inspiration it moves forward an inch.

The clavicle exerts marked influence over the appearance of the neck. As is known, the neck varies greatly in apparent length in different individuals; this difference, evidently, does not depend upon the variations in the measurements of the cervical vertebræ, for these are slight, but upon the position of the clavicles. In individuals of robust habit and large respiratory capacity the clavicles are forced up to a higher plane than in those persons of weak muscular power, whose respiratory capacity is small.—In the corpulent, the subjects of organic heart disease or of

[1] Dublin Journal of Medecine, lvi. 413, 1873, one instance, fig. with scapula; Ibid. lx. 166, 1875, three instances, one with scapula, figs.

[1] Jenaische Zeitschr., Bd. I. 1866.

[2] Lehrbuch der Anatomie des Menschen, 104.



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emphysema, the clavicles are raised and the neck is shortened; while in the subjects of phthisis they are depressed, the shoulders are sloping, and the neck is lengthened. In the full-chested the clavicles pass almost horizontally outward; in the narrow-chested they incline markedly backward. The last-mentioned position of the clavicles is so invariable that it may be taken into account in examination for the early stages of chronic phthisis.—In a condition which may be taken as an average, the median third of the bone answers to the first rib, which it crosses at an acute angle; the middle third to the first intercostal space, from which it is separated by the branchial plexus and the axillary vessels; and the outer third to the coracoid process and the acromio-clavicular articulation.—Enlargements of the subclavian artery and vein can in certain abnormal states aid in pushing up the clavicle, and together with the other causes already mentioned disturb the normal relation of parts at the base of the neck. Operations for aneurism or for subclavian tumors of any kind are from this cause more difficult than would appear from the study of the comparatively superficial structures met with in the subject. Indeed, so great is the difficulty arising from the depth at which the artery may lie that division of the clavicle has sometimes been resorted to prior to ligation of the subclavian artery at its outer third.—In cases of comminuted fracture the internal jugular vein and the subclavian vein have been punctured or compressed. The compression may involve the subclavian artery, and the pulsation of the radial artery may be suspended. Enlargement in the volume of the bone is liable to create similarly injurious pressure. When this is excessive, the expansion of the chest-wall is so interfered with as to create dyspnœa.[1]—In fracture of the bone at the junction of the thoracic end and the body, the former end is fixed by the costo-clavicular ligaments, while the remaining portion of the bone is depressed by the weight of the superior extremity, and the median end is elevated. In fracture of the body (a result of falling upon an outstretched hand) the median fragment is raised by the Sterno-Cleido-Mastoid muscle, the lateral fragment is depressed, and the free end drawn forward, inward, and backward by the action of the shoulder muscles. In the rare fracture between the two divisions of the coraco-clavicular ligament, no displacement occurs; but in fracture to the outer side of this ligament the lateral fragment is pulled downward by the weight of the superior extremity until it is nearly at a right angle to the rest of the bone, which remains in position.

[1] John Britton, British Med. Journ. 1870, 519.

THE SCAPULA.

The scapula or shoulder-blade (figs. 1, 2, Plate XXVII.; fig. 1, Plate XXVIII.) is the main bone of the shoulder. It belongs to the class of the flat bones, is for the most part thin, and possesses a somewhat triangular form. It is situated at the side and at the back of the thorax, and when at rest corresponds to the distance between the second and the seventh or the eighth ribs. The scapula is a very movable bone, owing to its connection with the trunk by means of the clavicle, and to the numerous powerful muscles inserted into it.

The scapula presents for examination two surfaces, three borders, and three angles. The neck, the glenoid cavity, the coracoid process, the spine, with the acromion, are also described.

The *dorsal surface* (dorsum) is divided at its upper fifth into two unequal portions by the *spine*. That portion above the spine is called the *supra-spinous fossa*, and that below the spine the *infra-spinous fossa*. The supra-spinous fossa is concave, and broader toward the vertebral than the axillary border. It gives origin to the Supra-Spinatus muscle.—The infra-spinous fossa is, for the most part, convex for the origin of the Infra-Spinatus muscle, but exhibits a longitudinal depression toward the robust axillary border. Below and to the axillary side of the Infra-Spinatus impression lies the narrow surface of origin of the Teres Minor muscle. Crossing the axillary limit of the fossa at its upper third is a transverse *groove* for the dorsal scapular artery. At the inferior narrow portion of the infra-spinous fossa, below the surface for the last-mentioned muscle, is a smooth triangular space for the origin of the Teres Major muscle. This is limited above by an oblique line separating it from the impression for the Teres Minor. Above the axillary limit of the Teres Major impression is seen the small surface of origin of the Subscapularis muscle, which is occasionally present.

The *under surface* (venter) extends the entire length of the bone. It is concave, and at its upper fifth, viz. at the point corresponding in position to the spine of the scapula, it presents a somewhat pronounced depression, which has received the name of the *subscapular angle*. Below this depression, the subscapular fossa is marked toward the vertebral border by three

or four faint ridges, which serve as points of attachment for the inter-muscular septæ of the Subscapular muscle. Along the vertebral border itself is a rough line for the insertion of the Serratus Magnus.

The *borders* (costæ) of the scapula are the upper, the vertebral, and the axillary.

The *upper border* is thin, and it extends between the superior angle and the *supra-scapular notch*, which transmits the supra-scapular nerve and vein. To the vertebral side of the notch is attached the Omo-Hyoid muscle.

The *vertebral border*, (median[1] inner, internal, posterior,) or *base*, is somewhat thicker than the upper, and is divided by the spine into two portions. Holding the bone in its natural position, so that the dorsal surface remains in full view, the portion of the vertebral border *above* the spine inclines upward and forward; the portion *below* the spine inclines downward and forward. The supra-spinous border receives the insertions of the Levator Anguli Scapulæ and of the Rhomboideus Minor muscles, besides yielding some fibres of origin of the Supra-Spinatus muscle. The infra-spinous border receives the insertion of the Rhomboideus Major muscle.

The *axillary border* (lateral, external, outer, anterior) extends from the glenoid cavity to the inferior angle, and is remarkably thick as compared to the other borders. It is more compressed below than above, where its sides are lost on the neck. Directly beneath the glenoid cavity, with a slight inclination to the ventral surface, is the rough *impression* (infra-glenoid tubercle) for the origin of the long head of the Triceps muscle. Extending thence downward along the greater portion of the border is a *ridge*, which serves to separate the impressions for the Infra-Spinatus and the Subscapular muscles. The axillary border between the termination of the ridge and the angle is occupied by a thin broad spine of varying size, which is continuous with the surface on the dorsum for the Teres Major muscle.

The angles of the scapula are the superior, the inferior, and the glenoid (external). The *superior* is defined by the junction of the upper and the vertebral borders; the *inferior* by the junction of the vertebral and the axillary borders. In examinations of the living subject, the inferior angle is from its prominence often briefly called the *scapular angle*. On the dorsum the last-named part of the bone gives origin to a slip of the Latissimus Dorsi muscle. The *glenoid* angle (external) is represented by the position of the glenoid cavity, and, while essential to the figure of the scapula, is less exact than the other angles. Its description is included in the account of the neck.

The *neck*, unlike the part so named in other bones, is the most important division of the scapula when viewed from a mechanical point. It constitutes that massive portion of the bone which is defined on the axillary side by the swollen edge of the glenoid cavity, and on the vertebral by the base of the spine. A line continued from the last-named point downward to the venter would intersect the axillary border at the impression of the scapular head of the Triceps muscle, as a line continued from the same point upward would intersect the base of the coracoid process. On the venter itself no lines defining the neck exist. A portion of the neck is, therefore, continuous below the spine with the infra-spinous fossa, and above the spine with the supra-spinous fossa. The neck, as above defined, is spoken of by some authors as the *surgical neck* (Fig. 69); the *anatomical neck*, so called, being restricted to a line passing round the edge of the glenoid cavity.

Fig. 69.

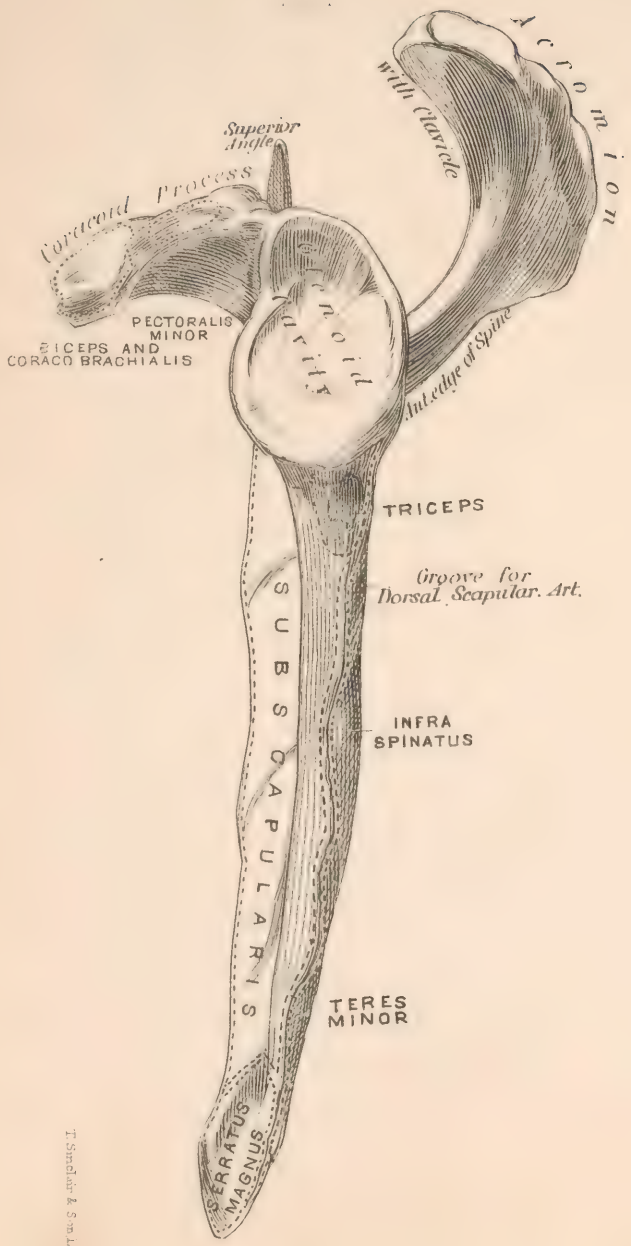


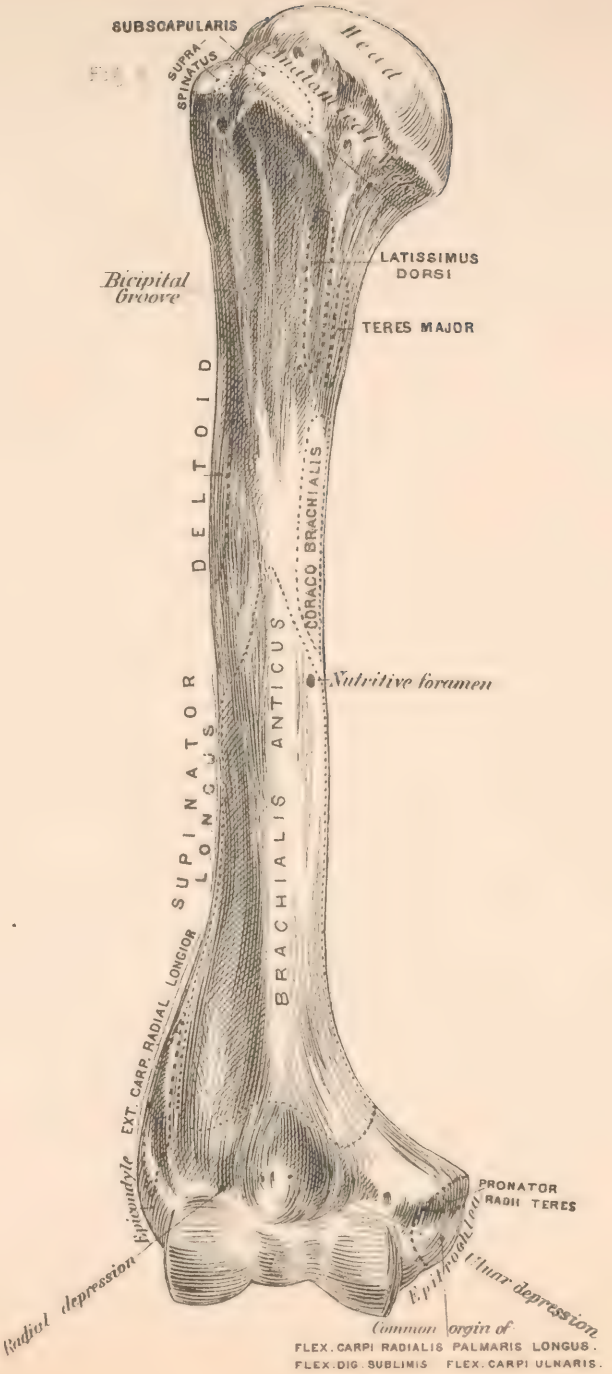
Scapula showing the line of fracture in the Surgical neck. It will be seen that the coracoid process and the glenoid cavity are included in the median fragment.

The *glenoid cavity* (glenoid head) is the surface by which the scapula articulates with the humerus. It is uniformly concave, and is semicircular at its lower, but acuminate at its upper half. Its ventral surface is slightly notched on the level with the base of the coracoid process. Superiorly, the cavity is continuous by an everted surface with the *supra-glenoid tubercle* for the origin of the long head of the Biceps muscle. The rim of the cavity is in connection with the glenoid ligament, which serves to deepen the articular surface during life.

The *coracoid process*, so called from its fancied resemblance to a crow's beak, arises as a stout column

[1] The term "median" is in this instance employed by German writers, since this border is nearer to the median line of the back than the "lateral" (axillary) border is to the median line of the sternum.





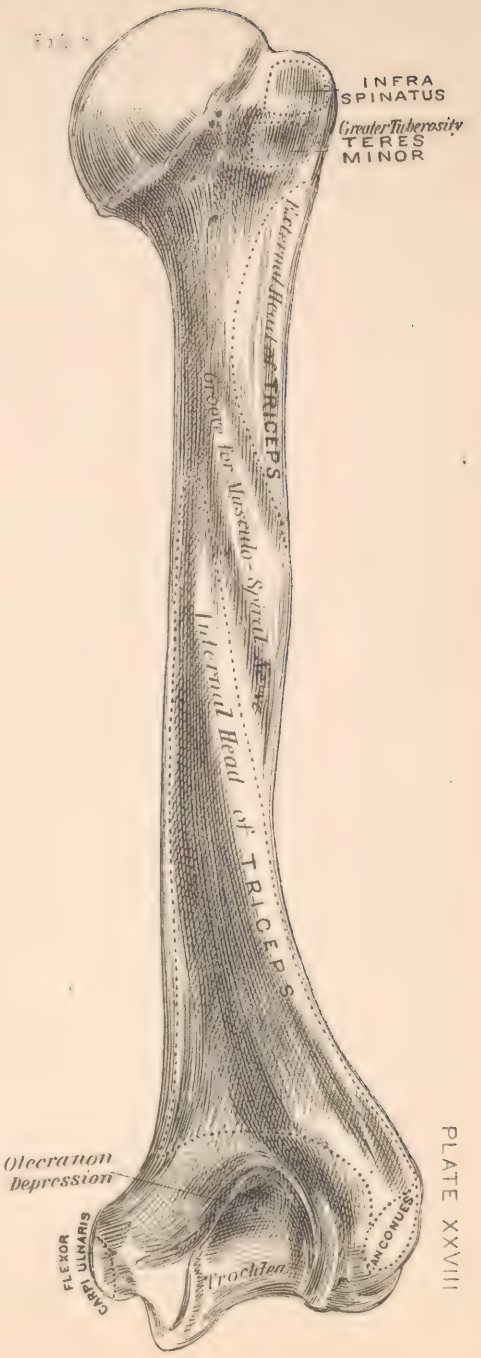


PLATE XXVIII

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from the entire upper border of the neck. It ascends on the level of the plane of the neck as far as the upper border of the bone, whence it is abruptly deflected downward and forward to end in a narrowed tip. Above, the coracoid process is roughened for the attachment of the acromio-coracoid and the coraco-clavicular ligaments. Exteriorly it yields a point of insertion for the Pectoralis Minor muscle, and of origin for the conjoined head of the Coraco-Brachialis muscle and the short head of the Biceps. The coracoid process acts as a check to the inward movements of the head of the humerus, and unless the process be broken subclavicular dislocation can scarcely occur. The process is homologous with the coracoid bone of batrachians, reptiles, and birds. As seen in these animals, the coracoid bone extends between the sternum and the scapula very much after the manner of the clavicle in the human subject.

The *spine* extends transversely to the plane of the dorsum at its upper third. It is of a triangular form, its face being outward; it begins by a smooth space on a level with the dorsum at the vertebral border of the bone (sometimes called the *root of the spine*), over which the Trapezius muscle glides; thence it inclines slightly upward as it reaches the region of the neck, to terminate abruptly below in a thickened rounded edge; above it widens, and is continuous with the acromion. The upper surface of the spine is concave for the Supra-Spinatus muscle; the lower is inclined upward for the Infra-Spinatus muscle. The Trapezius muscle is attached to the edge of the spine above and to the Deltoid below. The *acromion* is the name given to the tip of the spine as it overlooks the neck of the scapula. The space between the acromion and the neck has received the name of the *great scapular notch*. The acromion is a broad flattened process deflected toward the coracoid process, the plane of whose tip it reaches, and it is curved concentrically to the head of the humerus, which it helps to retain in position. The axillary rounded border of the acromion is continuous with the lower margin of the spine, and gives origin to the middle fibres of the Deltoid muscle; the vertebral border (upper, external) is continuous with the upper margin of the spine, and is furnished with an oval smooth facet for articulation with the clavicle. The inclination of this facet upward and backward accounts for the difficulty of retaining in position the scapular end of the clavicle after its dislocation.

Structure.—The scapula presents the strongest arrangement of the cancelli at the neck. The lines here radiate from the glenoid cavity toward the vertebral border. They are intersected by a number of laminæ that are more or less concentric with the plane of the articular surface. When it is remembered that no weight is borne by the scapula, the arrangement of cancelli of the neck can have relations with forces exerted from below only—namely, from the humerus. The pressure of the head of the last-named bone against the lower half of the glenoid cavity is very great when the arm is elevated by the Deltoid and the Supra-Spinatus muscles. The object of the cancelli in the scapular neck is to receive and distribute through the scapula the results of such pressure. Spongy tissue is also seen in the coracoid process, acromion, and spine, and at the borders and inferior angle of the bone. The greater part of the supra- and infra-spinous fossæ are thin and diaphanous.

Development.—The scapula arises from eight centres of ossification, as follows: one for the body, which appears at the eighth week; one for the coracoid process, which appears at the first year; and one for the glenoid cavity, embracing the supra-glenoid tubercle. These three centres are primary. The remainder are accessory centres, and may be thus briefly enumerated: one for the base of the acromion, appearing at the fifteenth year; one for the tip of the acromion, appearing at the sixteenth year; one for the base of the coracoid, at the seventeenth year; one for the inferior angle of the bone, at the sixteenth year; and one for the posterior border, at the seventeenth year. The centres for the acromion unite with the spine from the twenty-second to the twenty-fifth year. The marginal epiphyses unite with the body at about the twenty-fifth year. The acromion may exist as a distinct bone. In disjunction of the acromial centre it is not so often the entire acromion as it is the portion bearing the facet that is separate.[1] Even in the normally constituted bone the acromial centre can be distinguished; inferiorly it is of coarser texture than the spine, and everywhere pitted.—The coracoid process beyond the plane of the upper border of the bone is less frequently seen separated than is the acromion. It becomes a very important point to distinguish such a condition from fracture of the coracoid. While it is true that fracture of the process may occur at the point of junction of the centre and the base of the process, it is equally true that it is not apt to occur—the line of fracture

[1] H. Ruge. Zeitschr. für rationale Med., 1859, 258. W. Gruber. Bull. de l'Acad. de St. Petersbourg, 1859.

most commonly involving the neck of the scapula, with which, as has been shown, the process is continuous superiorly.—The centre for the inferior angle is sometimes united to the body of the bone by synchondrosis. Portal mentions the possibility of the detachment of this bone by the violent action of the Latissimus Dorsi muscle.

Remarks.—The variations in the scapula, apart from errors of development, are for the most part confined to the conversion of the supra-scapular notch into a foramen by the ossification of the transverse ligament; to the occasional flattening of the venter above the subscapular angle; and to the exaggeration of the spine in the axillary border.—The articulation between the scapular spine and the clavicle, described under the bone last named, is always accompanied with changes in the form of the spine and the adjacent parts. Should a specimen of a scapula come under notice in which irregular nodosities or ossifications are found attached to the upper border of the spine near the acromion, the inference is reasonable that the clavicle of the corresponding side had secured an articulation to the spine in addition to that of the acromion, and that the nodosities were in some manner associated with such abnormal union.

The coraco-clavicular ligaments are sometimes ossified in whole or in part, and aid in altering the outline of the neck. This occurs either as a result of united fracture of the scapular end of the clavicle, or as a result of the friction of the coracoid process against the clavicle. Under the last-named circumstance an adventitious joint or bursa may be developed, about which irregular ossific growths arise.

Under the action of osteophytes developed about the head of the humerus the glenoid cavity and the neck may be actually bisected as with a knife.

The greatest breadth of the scapula is obtained by a line extending from the centre of the glenoid cavity to the vertebral border; the greatest length by a line extending from the superior to the inferior angle. The length of the infra-spinous fossa is obtained by a line extending from the vertebral end of the spine to the inferior angle. The expression of proportion between the breadth and length has received from Broca[1] the name of the *scapular index*, and the length of the infra-spinous line, taken in connection with the other, the *infra-spinous index*. The standards thus accepted furnish means of examining scapulæ, not only for clinical purposes in health and disease, but for all other purposes of comparison.

The general form of the scapula can be made out in the living subject; the most easily determined features are the spine, the acromion, the vertebral border, and the inferior angle. Holden[1] suggests that measurements of the arms be taken from the junction of the spine and the tip of the coracoid process.—The posterior surface of the acromion is often separated from the skin by a bursa.

The position of the bone may be precisely stated as follows: The scapulæ are five and a half inches apart at the level of the spines, and six inches at the inferior angles. This distance may be lessened in muscular subjects; Meckel[2] states it at two inches. The spine is on a level with the third dorsal spine; it about answers to the division between the upper and the lower lobes of the lungs, and near the vertebral border is on a level with the third intercostal space.

The motions of the scapula are determined by the muscles in connection with it, and by the condition of the thoracic wall; and it may be thus thrown out of position by muscular atrophy or deformity of the spine. The scapulæ can be approximated so that the spines are an inch and a half apart, and the lower angles three inches apart. When widely separated the spines are nine inches apart, and the inferior angles thirteen inches. When the hands are crossed on the head, the inferior angles are sixteen and a half inches apart. In inspiration the scapula moves forward one inch, the spines are five inches apart, and the inferior angles seven inches, while the shoulders assume a square appearance. In respiration the scapulæ drop slightly, and project backward at the inferior angles. These projections, when very pronounced, have received at the hands of the older writers the name of the *scapular wings*. They are specially noticeable in chronic phthisis.[3]

By the motion of the scapula against the ribs, which Henke has somewhat fancifully compared to a ball-and-socket joint, a bursa, *bursa mucosa intra-serrata*, is apt to be developed between the concave scapula and the convex side of the thorax. Gruber has found that in about one-fifth of such instances an elevation of cartilage exists upon the third or the fourth ribs, over which the scapula glides. Dr. R. Herse[4] describes clinically a case in which the above condition was

[1] Bulletin de la Soc. d'Anthropologie de Paris, i. (3d series), 1878, 66; also, W. H. Flower, Journ. of Anat. and Phys. xix. 1879, 13.

[1] Landmarks, 104.
[2] Anatomie, i., 467.
[3] Sibson, Medical Anatomy Col., 45.
[4] N. Y. Med. Journ., xiii. 729

diagnosed. Galvagni[1] describes a crepitation accompanying the scapular movements, which is probably caused by the rubbing of the bone directly against the Serratus Magnus, and indirectly against the ribs.

The scapula may be excised, *and yet the usefulness of the arm be preserved.* Dr. M. Schuppart[2] describes such a condition. The motions of the arm while impaired were reasonably efficient. A weight of thirty pounds could be lifted and thrown a fair distance.

THE HUMERUS.

The humerus (figs. 2 and 3, Plate XXVIII.) is the largest bone of the superior extremity. It articulates above with the scapula, and below with the bones of the forearm. The humerus consists of a head, the anatomical and the surgical necks, the greater and the lesser tuberosities, the shaft, the epitrochlea, the epicondyle, the trochlea, and the radial head. It is convenient in addition to use the terms upper and lower extremities, which, while not exact, assume the bone to be divided into two parts, one above and the other below the junction of the upper third with the lower two-thirds of the shaft.

The *shaft* or *body* is subcylindrical above, and increases in bulk as it approaches the upper extremity; it is somewhat prismatic below, is compressed from before backwards, and is widened as it reaches the lower extremity.

The *head* is a large convex surface, which is a little longer than wide for articulation with the glenoid cavity of the scapula. It represents about a third of a sphere, and is directed upward and inward. It is bounded at its upper two-thirds by a *groove*—better marked behind than in front—known as the *anatomical neck.* To the outer side of the anatomical neck are two prominences, the greater and the lesser tuberosity. The *greater tuberosity* (radial tubercle) is continuous with the shaft, where it is covered by the Deltoid; it is marked on its sides by a number of minute pits and foramina, and above by a smooth surface obscurely divided by three facet-like depressions arranged from within outward for the insertion of the Supra-Spinatus, the Infra-Spinatus, and the Teres Minor muscles. The *lesser tuberosity* (ulnar tubercle) lies to the median side of the former, and is covered by the Biceps muscle. It is less abruptly separated from the shaft than is the greater, and receives the insertion of the Subscapularis muscle.

Between the tuberosities is a deep, vertical depression, the *bicipital groove*, which advances a short distance on the shaft, and receives the long tendon of the Biceps muscle.—The line of the lateral (outer) lip of the groove corresponds to the median border of the greater tuberosity, and also to a ridge that extends downward as far as the middle of the shaft. The ridge is roughened two inches below the head for the insertion of the Pectoralis Major muscle, and at its lower end by the median boundary of an irregular muscular impression (*deltoid impression*) for the insertion of the Deltoid muscle. The deltoid impression itself is a large V-shaped space, and lies on the lateral surface of the shaft.—The line of the median lip of the bicipital groove answering to the lateral border of the lesser tuberosity is less pronounced than the lateral lip. It receives the insertion of the Teres Major and the Latissimus Dorsi muscles.—The portion of the shaft between the insertion of the three muscles above named and the head has received the name of the *surgical neck.* At the median (inner) side of the shaft, at a point on the level of the insertion of the Deltoid muscle, is a faint and narrow impression for the insertion of the Coraco-Brachialis muscle. Immediately beneath the lateral border of the deltoid impression, and extending thence from before backward, is the *spiral groove*, for the musculo-spiral nerve and the superior profunda branch of the brachial artery. The posterior surface of the shaft below the line of the groove is smooth and nearly flat, for the origin of the internal head of the Triceps muscle. The anterior surface below the deltoid impression is abruptly convex, more markedly so above than below, for the origin of the Brachialis Anticus muscle. Separating the anterior from the posterior surfaces are two vertical ridges: the outer, the *supra-condyloid ridge* (supinator ridge), extends from the spiral groove to the epicondyle; the inner, the *supra-trochlear ridge*, extends from the insertion of the Coraco-Brachialis muscle to the epitrochlea. Both these ridges serve to give attachment to intermuscular septæ. The *foramen for the nutritious artery* (nutritive artery) of the shaft is seen at the upper end of the supra-trochlear ridge, with its orifice directed upward.

The *trochlea* is a cylindroid articular surface, placed transversely to the axis of the bone, and depressed in the centre; it articulates with the greater sigmoid notch of the ulna. The trochlea is broader and deeper behind than in front, and is inclined slightly, so that the middle of the upper trochlear margin in front lies to the median (inner) side of the axis of

[1] Stricker's Medecin. Jahrbuch. 1873, ii.

[2] New Orleans Journal of Medicine, Jan. 1870.

the humerus, while behind it is inclined to the lateral (outer) side. The trochlea is more sharply defined medianly than laterally. It is simple and concave behind, but presents in front, in addition to a central concavity, a convexity toward its median side. To the lateral side of the trochlea, and separated from it by a groove, is a well-defined convex surface, *the radial head* (condyle, capitellum), for articulation with the depression on the head of the radius. It is directed forward, and is confined to the anterior aspect of the bone.

Above the trochlea in front is a shallow triangular *depression for the coronoid process of the ulna.* A less distinct impression is seen above the radial head. Directly above the trochlea behind is a broad deep *depression for the olecranon.* To the lateral (outer) side of the radial head is a depression for the external lateral ligament; above it is seen a conspicuous tubercle—the *epicondyle* (external condylar eminence), for the origin of the extensor muscles of the forearm. To the median (inner) side of the trochlea is a process corresponding to the foregoing, but much more conspicuous than it—the *epitrochlea* (internal condylar eminence). This is roughened at the tip for the attachment of the internal lateral ligament of the elbow-joint, and in front for the origin in great part of the flexor muscles of the forearm.—The region of the epicondyle is much thicker than that of the epitrochlea; in some morbid conditions the disproportionate thickness between the two becomes enormously exaggerated.

Structure.—At the head are presented two sets of lines, a median and a lateral. The median set is composed at its outer border of nearly vertical lines, which pass downward from the upper border of the head to the median border of the anatomical neck. The inner members of this series become curvilinear and shorter as the lower border of the articular surface is reached. Thus the first of the central lines are the longer, and the last the shorter.—The outer set is composed for the most part of vertical lines passing through the greater tuberosity to the lateral wall of the anatomical neck. The median laminæ of this set become more and more oblique, and finally intersect the lateral fibres of the inner set.

At the distal end the laminæ, when seen in transverse longitudinal (frontal) section of the bone, are nearly vertical at the centre, but are moderately concave at their nearest border at the sides. Near the position of the epicondyle and epitrochlea are a number of oblique lines. In the longitudinal antero-posterior (sagittal) section lines are seen to converge from the articular surface to the compressed layer between the olecranon fossa and the depression for the coronoid process of the ulna.—In addition to the above arrangement the epiphysis can be distinguished from the shaft by the fine texture of the cancelli lying beneath the articular surface, and by the coarse and for the most part vertically arranged laminæ of the greater tuberosity. In some specimens the two sets of the shaft, instead of being straight, are slightly curved toward each other.—Notwithstanding the strength of the humerus, numerous examples are on record of its fracture by muscular action.[1]

Development.—The humerus arises from seven to eight centres of ossification. The first centre appears in the shaft at about the eighth week; the nucleus for the head appears at the second year, and that for the great tuberosity at the third year. The lesser tuberosity, should it have a distinct centre, ossifies at the fifth year. The centres above named coalesce by the fifth year, and constitute the upper or proximal epiphysis. The union between it and the shaft takes place at about the twentieth year. The radial head is the first portion of the distal end of the bone that ossifies, since it receives its centre at the third year. The remaining parts ossify in the following order: the epitrochlea at the fifth year, the trochlea at the eleventh or the twelfth year, and the epicondyle at the eighteenth year. The distal end when completed unites with the shaft at about the sixteenth or the seventeenth year.

A transverse line drawn below the tuberosities defines the distal limit of the proximal epiphysis, as a similar line uniting the proximal borders of the epitrochlea and the epicondyle defines the proximal limit of the distal epiphysis. Both of the epiphyses may be violently detached in the living subject (Fig. 70). In the event of the proximal epiphysis becoming detached, it has been found by Mr. Jno. Hutchinson[2] that the periosteum is apt to be stripped off from the proximal end of the distal fragment of the shaft, and left attached as a dense cup to the distal edge of the proximal one. This circumstance leaves the epiphysis with more muscular fibres attached to it than would have been the case were a clean section made through the bone and the periosteum. Thus, the Teres Minor muscle is inserted distally to the ephiphyseal line, but

[1] Hamilton on Fractures and Dislocations; and W. Parker, N. Y. Journ. Med., 1852, 95.

[2] Med. Times and Gazette, 1866, 248.

is nevertheless apt to remain with the periosteum belonging to the proximal fragment.[1] The distal epiphysis may be detached entire, or the mass composed of the radial and trochlear centres may remain in

Fig. 70.



Humerus showing separation of the proximal epiphysis.

connection with the shaft, and either the epicondyle or epitrochlea be detached. Luschka mentions an example of the former in which the centre, while detached, still retained a quasi connection with the shaft by cartilage.

Remarks.—The bones of the superior extremity are generally described as though the forearm and the hand were strongly supinated. This position so places the humerus that its deltoid surface moves from an anterior to a lateral (external) position, and its bicipital from a median (internal) to an anterior. The physician, however, will rarely be required in making examinations to place the limb in this unusual position. It is advisable that the bones should be studied as they are seen in the position of rest, namely, with the hand and forearm pronated. Thus seen, the deltoid surface of the humerus is directed forward and slightly outward, and the bicipital groove forward and slightly inward. The lower extremity is not at a right angle to the axis of the trunk, but hangs obliquely so that the epicondyle is on a plane in front of the epitrochlea.

The varieties in the shape of the humerus are not numerous. One of the most striking is an angulation of the shaft at the position of the insertion of the Deltoid muscle, and at first sight it appears to be the result of this muscle's traction on the bone. The shaft above the angle is directed inward and backward, and the bone about the angle is sometimes thicker and rougher than is the rule. The last-named appearance, when taken in conjunction with the apparently *bent* shaft, has caused these specimens to be confounded with others that show effects of fracture. No mistake of this kind need be made if the side *opposite* to the angulation be examined. Should the specimen be one of old fracture, the opposite side will be uneven, while it is quite smooth in the variety of the normal bone just mentioned. The surface of origin of the third head of the Triceps muscle is often convex instead of flat, and may be the seat of localized ostitis.—The bases of the depressions for the olecranon and the coronoid processes may communicate with each other.

Under the name of the *supra-condyloid process* is described as a rare anomaly a slender process projected from the median border of the bone above the internal condyle (epitrochlea). It is supposed to be a rudiment of an osseous bridge that defines a foramen seen in this position in some quadrupeds, as in the dog and the raccoon. The Pronator Radii Teres muscle may arise by means of a thin fibrous band from this process.[1]

The shape of the humerus can be with relative ease defined under the skin. Among the more conspicuous points may be mentioned the greater tuberosity, the general direction of the bicipital groove, the epitrochlea, and the epicondyle. The fingers, pushed well up into the axilla, will be found to reach the shaft at the surgical neck. This method of examination is facilitated by a moderate degree of elevation of the arm.

According to Holden, it is just below the insertion of the Deltoid that ununited fracture of the shaft is seen, partly on account of the injury to the nutritious artery here situated, and partly on account of the action of the Deltoid muscle in causing a riding of the proximal fragment over the distal.—Old persons not infrequently suffer from fracture high up through the tuberosities, just as they are liable to fracture of the neck of the thigh-bone, and of the cancellous structure at the base of the trochanter.[2]

Exostoses have been seen occupying the position of insertion of the Pectoralis Major, the third head of the Triceps at its upper part, and the insertion of the Latissimus Dorsi. When such outgrowths occur, the portion of the shaft below the anatomical neck is

[1] Jno. Hutchinson, Med. Times and Gaz., March 10, 1866, 248.

[1] For literature and figures, see W. Gruber, Mem. Acad. of St. Petersburgh, 1859, 55; also, Jno. Struthers, Edin. Med. Journ., 1848, and Lancet, 1863, i. 87.

[2] Jno. Hutchinson, Med. Times and Gaz., 1866, 303.

remarkably inflated. Exostosis of the greater tuberosity has been successfully removed by operation.[1] The head of the bone has been known to be absorbed, as recorded in a case by Bull.[2]

THE ULNA.

The ulna (fig. 4, Plate XXIX.) is the longer of the two bones of the forearm. It articulates proximally with the trochlea of the humerus, distally with the carpus, and at the lateral side with the radius. It lies to the median side, and to some extent behind the radius. A line drawn downward through the radial head of the humerus would touch the lower end of the ulna.

The ulna is divided into a shaft, an upper and a lower extremity.

The *upper extremity* is of an irregular quadrilateral figure, deeply notched above to form the *greater sigmoid cavity*. The posterior limit of the notch forms the olecranon, and the anterior the coronoid process.

The *olecranon* is continuous with the shaft posteriorly. It forms a massive process, curved slightly forward, and is wider in front than behind. Its posterior surface is rounded for the insertion of the tendon of the Triceps muscle, while the summit is for the most part smooth for the accommodation of a large synovial bursa. A narrow *groove* between the site of the bursa and the free edge designates the line of attachment of the posterior and the lateral portions of the capsular ligament. Beneath the insertion of the tendon of the Triceps muscle is a free triangular surface, with the apex directed distally; the sides are defined by the approximation of the Anconeus and the Extensor Carpi Ulnaris muscles; it constitutes the portion of the bone felt beneath the skin in the undissected subject.

The *coronoid process* is continuous with the front of the ulna. It is a wide, compressed projection, having a broad base, and well-defined sides. Its anterior surface is flat or slightly concave, to receive, by a rough impression toward the median side, the tendon of the Brachialis Anticus muscle. At the base of the coronoid process is a slight elevation termed the *tubercle* for attachment of the oblique ligament. The line of junction at the median side between the coronoid process and the olecranon is depressed to give origin in part to the Flexor Carpi Ulnaris muscle, and to a slip of the Flexor Sublimis Digitorum. The lateral side of the coronoid process is depressed, and marked at the upper half by an elliptical concave articular surface—the *lesser sigmoid cavity*—for articulation with the head of the radius. The bone on either side of this facet is often roughened for the attachment of the orbicular ligament. Below the lesser sigmoid cavity the lateral surface is abruptly concave for the origin of a slip of the Supinator Brevis muscle.

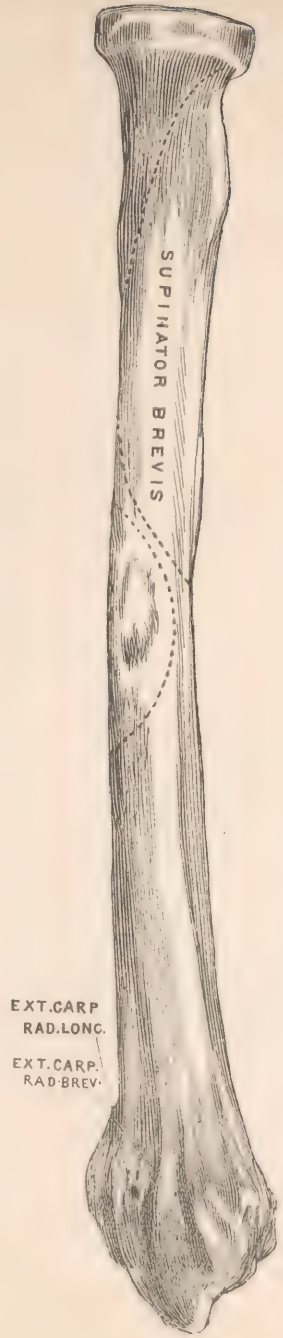
The *greater sigmoid cavity* in articulating with the trochlea of the humerus presents for examination two surfaces, one pertaining to the olecranon and the other to the coronoid process. These surfaces are separated by a transverse groove, which, beginning conspicuously at the middle of the median border, ends faintly at the corresponding point on the lateral border. At a right angle to this notch is a smooth vertical ridge which extends from the centre of the upper margin of the olecranon above to terminate at the anterior free margin of the coronoid process below, and which serves to divide the sigmoid notch into two unequal areas; of these areas the inner is the larger and more concave.

The *shaft* of the ulna is three-sided, and presents accordingly three surfaces for examination, an anterior, a posterior, and a median (inner). The *anterior* and *posterior surfaces* are sharply separated by a thin compressed *ridge*, which is well defined along the middle third of the lateral border, and which serves for the attachment of the interosseous ligament. The median (inner) surface is joined to the anterior by a rounded border, having imperfectly defined limits. The posterior surface is continuous with the anterior surface, excepting at its middle third, where it is separated by the ridge above named.

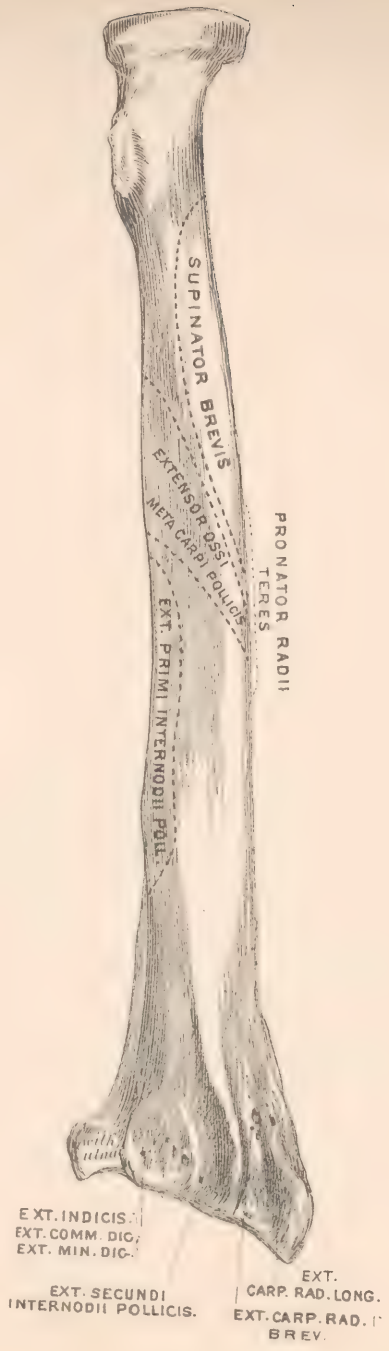
The details of the shaft, as included within the above-named borders and surfaces, are as follows: the *anterior* surface exhibits a longitudinal depression, for the origin of the Flexor Profundus Digitorum, extending downward and outward from the insertion of the Brachialis Anticus. The *oblique line* serves to separate the surfaces of origin of the Supinator Brevis from the Flexor Sublimis Digitorum; near this line, and toward the median border of the shaft, is seen the *nutritious foramen* directed from the upper extremity of the bone. Toward the distal extremity the anterior surface becomes narrower, and is marked by a line directed downward and inward, for the origin of the Pronator Quadratus. The *posterior* surface is limited laterally above by an *oblique line* or ridge, extending from the posterior border of the lesser sigmoid cavity downward and outward to separate the depression for the insertion of the Anconeus muscle

[1] Lancet, 1864, 210.

[2] Med. Times and Gaz., 1868, 498.


SUPINATOR BREVIS
EXT. CARP RAD. LONG.
EXT. CARP. RAD. BREV.


with humerus.
with ulna
Head
Neck
Bicipital
SUPINATOR BREVIS
BICEPS
FLEXOR LONGUS POLLICIS
PRONATOR QUADRATUS
SUPINATOR LONGUS
Styloid Process
with Semilunar and Scaphoid


SUPINATOR BREVIS
EXTENSOR OSSI METACARPI POLLICIS
EXT. PRIMI INTERNODII POLL.
PRONATOR RADII TERES
with ulna
EXT. INDICIS
EXT. COMM. DIG.
EXT. MIN. DIG.
EXT. SECUNDI INTERNODII POLLICIS.
EXT. CARP. RAD. LONG.
EXT. CARP. RAD. BREV.

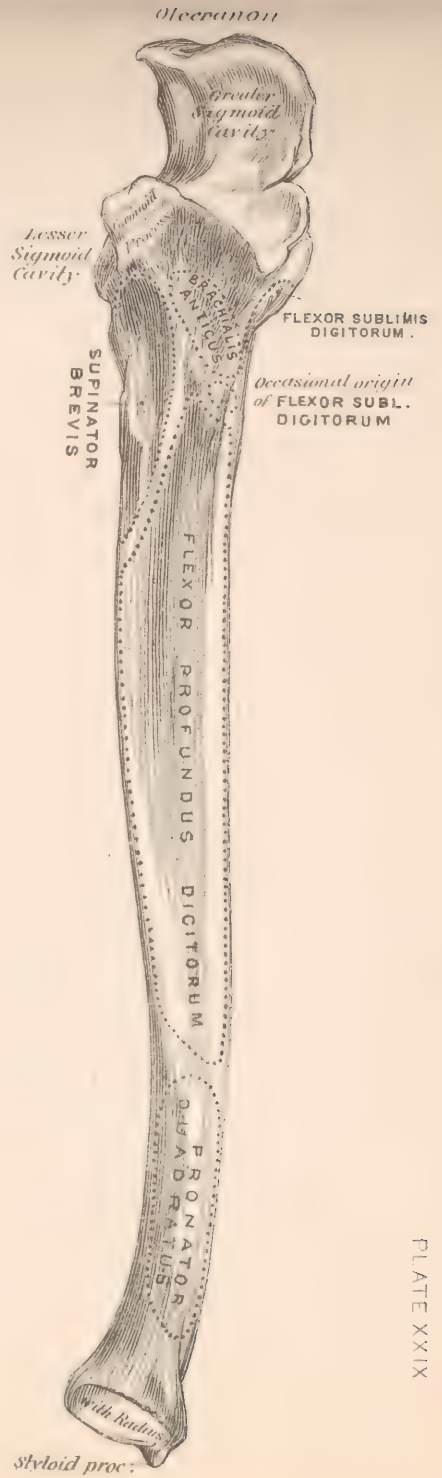

Olecranon
Greater Sigmoid Cavity
Lesser Sigmoid Cavity
BRACHIALIS ANTICUS
FLEXOR SUBLIMIS DIGITORUM.
Occasional origin of FLEXOR SUBL. DIGITORUM
SUPINATOR BREVIS
FLEXOR PROFUNDUS DIGITORUM
PRONATOR QUADRATUS
With Radius
Styloid proc:

PLATE XXIX

from the ulnar origin of the Supinator Brevis. To this succeeds a longitudinal *ridge*, whose hinder surface is slightly concave for the origin of the Extensor Carpi Ulnaris muscle. The outer, lower, and rougher parts of the posterior surface give origin to the extensors of the thumb, and in part to the Supinator Brevis muscle. The median border of the posterior surface is for the most part smooth and convex, being broad and concave at its upper portion for origin of the Flexor Profundus Digitorum. It is subcutaneous at its lower fourth.

The *lower extremity* of the ulna is sub-cylindrical in form, and concave on its anterior surface for the Pronator Quadratus muscle. The apparent constriction at this point has received the name of the *neck of the ulna*. The posterior surface is slightly concave for the tendon of the Extensor Carpi Ulnaris muscle. Its median surface is narrow, rounded, and produced posteriorly below the level of the main articular surface, and receives the name of the *styloid process*, and to it is attached the external lateral ligament of the wrist-joint. The tip of the process is covered with cartilage, and forms a constituent part of the joint. The articular surface of the lower extremity of the ulna is termed the *head*. It presents a rounded, nearly vertical lateral border, for articulation with the sigmoid cavity of the radius, and is continuous with the distal surface which is in apposition with the triangular cartilage of the wrist-joint, attached to the notch between the articular surface and the styloid process.

Structure.—The proximal end of the ulna presents a somewhat complex arrangement of laminæ. First in order is a series of nearly vertical lines extending from the great sigmoid fossa to the anterior surface of the shaft. Second, a small group of lines concentric with the curvature of the great sigmoid cavity at its lower half. Third, a series of scattered lines covering the olecranon obliquely from behind forward and downward. Fourth, numerous intersecting arching lines in the remainder of the extremity. The distal end is occupied by oblique, scarcely intersecting lines arranged as in the corresponding end of the radius.

Development.—The ulna arises from three centres of ossification. The nucleus for the shaft appears at about the eighth week; that for the lower extremity at the fourth or fifth year. The upper extremity, so far as it is articular, is an outgrowth from the shaft. An epiphyseal nucleus appears at the tip of the olecranon at the tenth year. This joins the shaft about the seventeenth year. The lower epiphysis unites with the shaft about the twentieth year.

The distal epiphysis has been frequently separated by violence, and in some instances has been necrosed and lost. It is interesting to know that a useful arm may result after this singular lesion. The olecranon and the coracoid process very rarely persist as distinct bones.

Remarks.—The shaft of the ulna is often obliquely deflected at the oblique line.—The olecranon is sometimes broken by a fall on the elbow, the fracture generally taking place at the constriction where the process joins the shaft—thus involving the joint. The coronoid process may be broken off by excessive strain of the Brachialis Anticus muscle. Liston mentions a case of this kind occurring to a boy eight years of age, in consequence of hanging with one hand from the top of a high wall. Fractures of the olecranon and the coracoid process unite, as a rule, by ligament.

When the ulna and the radius are in articulation, it is noticed that the styloid process of the former is somewhat shorter than that of the latter. Both it and the ulnar head can be made out in the undissected subject, lying between the Extensor Carpi Ulnaris and the Extensor Minimi Digiti muscles.

A sesamoid bone is rarely found lying in front of the coronoid process. In a case reported by Fischer,[1] it attained the size of a pigeon's egg.

THE RADIUS.

The radius (figs. 1, 2, 3, Plate XXIV.), while slightly shorter than the ulna, is more massive than that bone, and articulates with the radial head of the humerus above, the carpus below, and the ulna at its median (inner) side in such a manner as to secure movements that are much more varied than are those of the ulna. The part the radius contributes to the formation of the elbow-joint is small compared to that which it contributes to the wrist.

The radius consists of a shaft and an upper and a lower extremity. The bone is narrow and irregularly rounded above, broader and somewhat three-sided below. The *upper extremity* is termed the *head*. It is disk-shaped, with a depression above, as already mentioned, for articulation with the radial head of the humerus. The depression does not occupy the entire proximal facet, for at its inner side a crescentic con-

[1] Langenbeck's Archiv für Chirurg., 1871, xii. 863, figs. 9 and 10, tab. 15.

vexity is seen which articulates with a groove between the radial head and the trochlea. The head presents vertical borders, which are more pronounced within than without, for articulation with the lesser sigmoid cavity of the ulna, and the orbicular ligament. Below the head is a circular constriction—the *neck*. Directly beneath the neck at its anterior surface is the large rounded prominence—the *tuberosity*—the front aspect of which is smooth for the accommodation of a bursa, while the back part is roughened for the insertion of the tendon of the Biceps muscle. The *shaft* of the radius seen from the outer side at the position of the tuberosity is flattened and covered by the Supinator Brevis muscle.

Extending from the position of the tuberosity downward and outward as far as the outer surface of the shaft at about its middle is the *oblique line*. A little below the end of this line lies the roughened impression for the insertion of the Pronator Radii Teres. Thence to the distal end the shaft is somewhat three-sided. The *median* edge or border is sharp and compressed for the attachment of the interosseous ligament. The *lateral* surface or border is broad and convex, and covered by the tendon of the Supinator Longus muscle. The *anterior* surface is nearly smooth, and marked for the upper two-thirds by the origin of the Flexor Longus Pollicis muscle, and below (near the wrist) for the insertion of the Pronator Quadratus muscle. A short distance below the oblique line at the upper third of the shaft is the *nutrient canal*, the orifice of which is directed upward. The *posterior* surface is nearly plane, and covered with the Extensor Communis Digitorum.

The *lower extremity* is larger than the upper. It is somewhat irregularly quadrangular, and marked by the anterior, the lateral, the posterior surfaces (which represent corresponding surfaces of the shaft), and the median (inner) surface which is continuous with the median edge of the shaft.—The *anterior surface* is slightly concave, with sharply defined borders. Its median (ulnar) half projects a little forward, and answers to the semilunar bone; while the lateral (outer) half is deflected downward and outward to form the anterior surface of the *styloid process*, serves for the attachment of the capsular ligament of the wrist-joint, and answers to the scaphoid bone.—The *lateral* (outer) *surface* is broad, and defined in front by the sharp edge separating it from the anterior surface—and behind by a ridge, which is confined for the most part to the shaft, and terminates abruptly a short distance from the articular surface, and which separates the tendons of the extensors of the fingers from the tendons of the extensors of the carpus. The lateral surface is further distinguished by a central ridge confined for the most part to the epiphysis. It passes along the entire length of the styloid process, and separates the groove for the extensor of the metacarpal bone of the thumb, and of the first joint of the thumb, from the extensors of the carpus.—The *posterior surface* is generally described as included within the former. It is limited to that portion of the bone lying between the median and the lateral surfaces. It is nearly smooth, and occupied by the tendons of the extensors of the fingers, and marked at its outer border by a special groove (sometimes absent) for the Extensor Indicis muscle.[1]—The *median* (inner) *surface* is of a triangular shape, narrow above where it is continuous with the inner edge of the shaft, broader below where it joins the carpal surface at a right angle—and presents a facet called the *sigmoid cavity*, which is concave to articulate with the head of the ulna.

The *distal* or *carpal articular surface* is concave, and triangular in form, its base being directed to the median side. Its antero-posterior diameter is marked by a faint ridge which separates the lateral triangular facet for articulation with the scaphoid bone from the median more quadrangular facet for articulation with the semilunar bone.

Structure.—The direction of the laminæ is such that the lines pass downward somewhat convergingly from the proximal articular surface to the inner side of the neck. These are intersected so as to form narrow arch-like figures by lines starting from the sides of the bone. In the distal extremity the lines are oblique and, as such, pass downward from each side to the epiphyseal end, where they terminate with little or no intersection. The lines are more vertical at the outer border. A number of transverse lines are seen in the epiphysis.—In aged subjects the distal epiphyseal end becomes much weakened by reason of the partial atrophy of the cancelli. As a result fracture has not infrequently resulted in comminution of the distal end and inevitable shortening of the shaft of the bone.

Development.—The centre for the shaft of the radius appears between the fifth and the eighth week. The centre for the lower extremity appears at the second year, and unites with the shaft at the twentieth year. The centre for the upper extremity

[1] A portion of the lateral surface is seen in connection with the posterior when the bone is viewed from behind.

(head) appears at the fifth year and unites with the shaft about puberty.

Remarks.—The shaft of the radius may be deflected inward at the pronator impression.

The position of the radius can be determined in the undissected subject by the shaft. With careful manipulation the tubercle can be made out in forced pronation, while the styloid process and the lateral surface of the inferior extremity can be readily outlined. The advantage secured by defining this surface as distinct from the posterior is decided in studying the relation of the parts at the wrist. The lateral surface is easily detected beneath the skin, and the tendons of the pollical and the carpal extensors can be felt as the thumb and the hand are extended. The posterior surface in the subject cannot be limited medianly, but is bounded by the head of the ulna. The application of these facts in regional anatomy to the study of the lesion of Barton's fracture is so direct as to require no comment.—Surgical writers describe a depression on the lateral side of the olecranon, which answers to the head of the radius.—J. Kaczande[1] narrates an instance of congenital absence of the radius.

THE CARPUS.

The carpus (Plate XXX.) is a system of irregular bones placed between the bones of the forearm and the metacarpus. It is composed of eight bones, enumerated from the radial to the ulnar border, as follows: the scaphoid, semilunar, cuneiform, pisiform, trapezium, trapezoid, os magnum, and unciform. The figure of the carpus is broader than long, and slightly curved upon itself. It presents a slightly convex dorsal surface, and a concave palmar surface, which is deepened by lateral pressure—the tuberosity of the scaphoid, an oblique process of the trapezium lying at the lateral border, and the hamular process of the unciform at the median. Between these prominences the deep annular ligament is stretched. The proximal surface is smaller than the distal, and is convex for articulation with the radius and the triangular ligament. The distal surface is slightly curved downward, and, excepting a small surface of the trapezium between the first and second metacarpals, which is free, is designed for union with the metacarpus.

The bones of the carpus are arranged in two rows, named, from the proximal to the distal end, the first and the second row. The *first row* is composed of the scaphoid, semilunar, cuneiform, and pisiform bones; the *second row*, of the trapezium, trapezoid, os magnum, and unciform. Of these the pisiform alone presents but a single facet. The pisiform is the least important of the carpal bones, and pertains more properly to the muscles on the ulnar border of the forearm and hand.

The line between the two rows is called the *intercarpal* line.

The bones of the first row are so articulated as to yield an arch extending transversely. This is *concave* below, opposite the three outer fingers, in such a way as to secure the scaphoid and the cuneiform bones on the sides of a curve of which the semilunar bone is the centre, and which receives the *convexity* formed by the unciform bone and the os magnum.

Toward the radial border the first row presents a *convex* lateral surface confined to the scaphoid bone, which is received into a *concave* surface composed of the distal facets of the trapezium and the trapezoid bone. Thus the inter-carpal line is sinuous; it is curved forward for the carpal bones, answering in position to the thumb and index finger, and backward for those answering to the middle, the ring, and the little finger.

The bones composing the carpus are free for ligamentous and muscular attachment on the palmar and dorsal surfaces; they are faceted on the remaining sides, except at their entrance into the radial and ulnar border, where they are also free.

Structure.—Each bone is composed of cancelli, with a thin outer compact layer.

Development.—Each carpal bone arises from a single centre of ossification.[1] The os magnum ossifies at the first year; the unciform at the second; the cuneiform at the third; the trapezium and the semilunar bones in the fifth; the scaphoid in the sixth and seventh; the trapezoid in the seventh or eighth; and the pisiform at the twelfth year.

The motions of the carpus as a whole are limited to the radio-carpal joint. The second row is capable of being moved upon the first—as in the act of creeping. Here the portions of the hand supporting the weight of the body—viz., the phalanges, the metacarpus, and the second row of carpal bones—are extended upon the first row, which remains in direct

[1] Virchow's Archiv, 1877, 409.

[1] For the statement that the carpal bones may arise from more than one centre each, see Rambault and Renault, Origine et Developpement des Os. Paris, 1867.

line with the vertically placed bones of the forearm. The carpus for the main features of its mechanism is best studied in the act of transmitting the shock received through all the bones from the distal to the proximal ends. Thus, in striking with the fist, the force of the blow is received by the distal ends of the outer four metacarpal bones, through the flexed base of the first row of the phalanges. It is thence transmitted along the bones of the forearm (notably the radius) by means of the convergent axial lines of the carpal bones. Animals walking upon the ends of the toes, such as ruminants, horses, and others, retain the disto-proximal mechanism of the carpus still more conspicuously than does man.

The Scaphoid Bone.—The scaphoid bone (navicular bone) is the first bone of the first row. It articulates with the radius proximally, with the trapezium and the trapezoid distally, and with the os magnum to the ulnar side. The proximal surface is pyriform, the base being directed medianly, and lying in the palmo-dorsal axis of the bone; the distal surface is broader toward the palm than is the dorsum. Between the last-named surfaces a groove extends, which constitutes the dorsum of the bone, and is continuous with the radial border. The ulnar surface is crescentic and convex above for articulation with the semilunar bone, and oblong and concave below for articulation with the os magnum. The radial border is free and roughened for the attachment of the internal lateral ligament at the *scaphoid tubercle*, which can be distinguished during life lying to the median side of the extensors of the thumb.

The Semilunar Bone.—The semilunar bone is placed between the radius proximally, and the os magnum and the unciform bone distally; the scaphoid bone lies to the radial border, and the cuneiform to the ulnar. The proximal surface, which is triangular in form, with the base directed toward the radial border, and the dorsal angle produced, is convex for articulation with the quadrilateral facet of the distal end of the radius. The distal border is bi-faceted—the radial facet being concave for articulation with the os magnum, and the ulnar facet (often inconspicuous) being flat and narrow for articulation with the unciform bone. Both the dorsal and the palmar surfaces are free, the palmar being the larger of the two. Of the lateral surfaces of the semilunar bone the radial is crescentic in form, and smooth for articulation with the scaphoid bone, the ulnar is flat and oblique for articulation with the cuneiform.

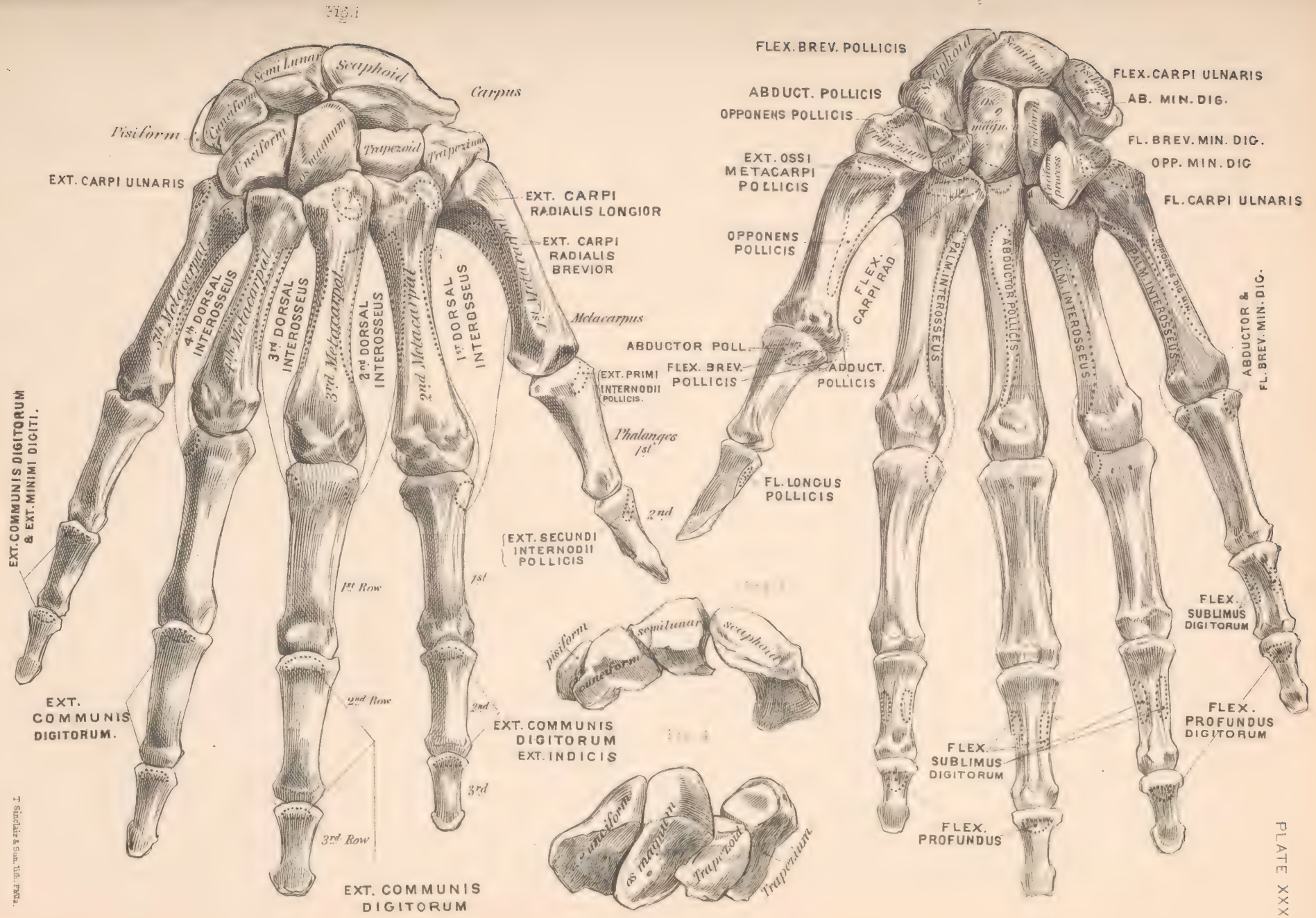
The Cuneiform Bone.—The cuneiform bone, as its name implies, resembles a wedge, with its base directed toward the radius. The largest articular surface—the distal—is saddle-shaped, broader above than below, and articulates with the unciform bone. A line carried back from it leads to a free dorso-lateral surface for the attachment of the external lateral ligament of the wrist-joint. There is thus no proper proximal surface of the bone. The dorsal surface is roughened for the ligamentous attachment at the ulnar half of the bone, but is convex and smooth for articulation with the fibro-cartilage of the wrist-joint. The palmar surface is irregular and roughened for attachment of ligaments. The radial surface presents a smooth facet for articulation with the semilunar bone; the ulnar is small, oval, smooth for articulation with the pisiform bone; a groove lies between facets of articulation with the pisiform and the unciform bones.

The outline of the bone can be made out in the undissected subject.

The Pisiform Bone.—The pisiform bone lies to the ulnar margin of the first row of the carpus on its palmar surface. It presents a single articular facet for the cuneiform bone, and lies to the ulnar side of the first row of carpal bones. The proximal, the distal, and the ulnar surfaces are free, receive the tendon of the Flexor Carpi Ulnaris muscle, and afford attachment to the external lateral ligaments of the wrist-joint. The bone also presents a facet for the Abductor Minimi Digiti muscles, and gives attachment to the anterior annular ligament.

The position of the pisiform bone can be easily recognized during life.

The Trapezium.—The trapezium is placed in front of the radial half of the distal surface of the scaphoid bone and proximally to the first metacarpal bone. It presents a distal saddle-shaped surface for articulation with the first metacarpal bone, and a proximal concave facet for articulation with the scaphoid bone. The dorsal surface is free, and exhibits two prominent tubercles in front, with an intermediate depression. The palmar surface is the most characteristic, and is marked by a wide compressed oblique process, for the origin of the Abductor Pollicis and the Flexor Brevis Pollicis muscles, and for the attachment of the deep annular ligament, as well as by a groove placed dorsally to the above-named process, for the tendon of the Flexor Carpi Radialis muscle as it passes to its insertion on the second metacarpal bone.


Fig. 1
Carpus
Pisiform
Cuneiform
Unciform
Semi Lunar
Scaphoid
Os Magnum
Trapezoid
Trapezium
EXT. CARPI ULNARIS
EXT. CARPI RADIALIS LONGIOR
EXT. CARPI RADIALIS BREVIOR
Metacarpus
1st
3d Metacarpal
4th Metacarpal
2nd Metacarpal
3rd Metacarpal
4th DORSAL INTEROSSEUS
3rd DORSAL INTEROSSEUS
2nd DORSAL INTEROSSEUS
1st DORSAL INTEROSSEUS
EXT. PRIMI INTERNODII POLLICIS.
Phalanges
1st
2nd
EXT. SECUNDI INTERNODII POLLICIS
EXT. COMMUNIS DIGITORUM & EXT. MINIMI DIGITI.
1st Row
2nd Row
3rd Row
EXT. COMMUNIS DIGITORUM.
EXT. COMMUNIS DIGITORUM
EXT. INDICIS
pisiform
cuneiform
semilunar
scaphoid
unciform
os magnum
Trapezoid
Trapezium
FLEX. BREV. POLLICIS
ABDUCT. POLLICIS
OPPONENS POLLICIS
EXT. OSSI METACARPI POLLICIS
OPPONENS POLLICIS
ABDUCTOR POLL.
FLEX. BREV. POLLICIS
ADDUCT. POLLICIS
FL. LONGUS POLLICIS
FLEX. CARPI RAD
PALM. INTEROSSEUS
ABDUCTOR POLLICIS
PALM. INTEROSSEUS
FLEX. CARPI ULNARIS
AB. MIN. DIG.
FL. BREV. MIN. DIG.
OPP. MIN. DIG
FL. CARPI ULNARIS
ABDUCTOR & FL. BREV. MIN. DIG.
FLEX. SUBLIMUS DIGITORUM
FLEX. PROFUNDUS DIGITORUM
FLEX. SUBLIMUS DIGITORUM
FLEX. PROFUNDUS
T. Sinclair & Son. lith. Phila.
PLATE XXX

Of the remaining surfaces, the radial is free and smooth, the ulnar is faceted for articulation with the trapezoid and the second metarcarpal bone. Between the distal facet and the ulnar border is a small portion of the trapezium, which lies free between the first and the second metacarpal bones, and serves for the attachment of a ligament.

Holding the bone with the grooved side downward, the saddle-shaped facet will point to the side to which the bone belongs.

THE TRAPEZOID BONE.—The trapezoid bone is placed between the radial half of the scaphoid bone proximally and the second metacarpal bone distally. It is narrow on the palmar surface, presents a nearly quadrilateral shape through the body, but is broad and irregular on the dorsal surface. The proximal surface is narrow, and yields a slightly concave facet for articulation with the scaphoid bone. The distal surface is saddle-shaped, with a median ridge, and articulates with the second metacarpal bone. The dorsal pentagonal surface is smooth and free, as is also the palmar. The radial surface articulates with the trapezium, and the ulnar with the os magnum.

THE OS MAGNUM.—The os magnum is placed between the semilunar bone and the ulnar surface of the scaphoid on its proximal side, and the third metacarpal bone on its distal side. The trapezoid and a portion of the second metacarpal lie to its radial, and the unciform bone to its ulnar side. The distal surface is triangular, and is concave for articulation with the third metacarpal bone. The proximal end forms the *head* of the bone; it is sub-rounded in form, and convex for articulation with the semilunar bone. The head is convex on its radial side, but flat on the ulnar, and is more conspicuous on the dorsal than on the ventral surface. The dorsal surface is marked by the facet for the semilunar bone proximally, but is broader and more irregular distally. The palmar surface is free, narrow, and convex. The radial surface constitutes a convex facet for articulation with the scaphoid; and a small median surface presents a facet for the trapezoid. The ulnar surface presents a facet along the entire length of the dorsal half of the bone for articulation with the unciform bone, while the palmar half is flat and roughened for ligamentous attachment.

THE UNCIFORM BONE.—The unciform bone is placed between the semilunar and the cuneiform bones proximally, and the fourth and the fifth metacarpal bones distally. The distal surface presents a large articular surface divided by a ridge into facets, as follows: the facet to the radial side of the ridge articulates with the fourth metacarpal bone, that to the ulnar side with the fifth metacarpal bone. The proximal surface is very oblique, and occupies the entire width of the bone. It is concave toward the ulnar side, convex toward the radial. A faint ridge defines the two facets: the first is very small, narrow, and convex at the radial edge for articulation with the semilunar bone; the second is large and, for the most part, concave for articulation with the cuneiform bone. The palmar surface is very irregular, and is marked, proximally to the fifth metacarpal bone, by a large hook-like process for the attachment of the deep annular ligament, and the origin of the muscles of the little finger. The surface elsewhere is narrowed. The dorsal surface is free. The radial surface is large, faceted nearly the entire surface for articulation with the os magnum; it becomes roughened in front for ligamentous attachment. The ulnar surface is compressed as a thin edge lying between the facet for the cuneiform and that for the fifth metacarpal bone.

Variations in the carpal and metacarpal bones are of four kinds: (1) Duplication of one of the bones; for example, the presence of two semilunar, or two scaphoid bones in the place of one. (2) The existence of the styloid process of the third metacarpal as a distinct bone. (3) The occurrence of an intermediate bone (*os intermedium*) between the scaphoid and the os magnum. This is homologous with a larger bone in the same locality, which is normal in the carpus of some of the quadrumana. (4) A sesamoid bone at the insertion of the Extensor Carpi Ulnaris.

All of the above variations are rare. They have been particularly investigated by Gruber.[1]

THE METACARPUS.

The metacarpus (Plate XXX.) is a series of cylindrical bones placed between the carpus and the first row of phalanges. Each bone consists of a shaft, a proximal (carpal), and a distal extremity. The shaft, which approximates a prism in form (an appearance best seen in the second, the third, and the fourth bones) is slightly concave beneath. The proximal end is flat or concave, and presents in the case of the second, the third, and the fourth bones lateral facets for articulation with the adjoining carpal bones. The distal extremity is rounded, convex, and, with the exception of the first, longer than wide.

[1] Arch. Anat. Physiol. und Wissensch. Med., 1862–76; Bulletin de l'Acad. Imp. St. Petersbourg, 1870–73.

In general outline the first metacarpal bone resembles a phalanx. It is shorter and wider than the others, and is placed at a greater angle to the carpus. It is flat on the dorsal surface, and slightly concave, with a tendency to the formation of a ridge, on the palmar surface near its carpal extremity. The proximal surface is saddle-shaped. The distal surface is produced a little toward the palmar aspect. The articular surface is broader than it is long, and presents on the sides two small facets for the sesamoid bones of the Flexor Brevis Pollicis muscle.

The second metacarpal bone is ridged above at the proximal half of the dorsum for the Dorsal Interosseous muscles. The proximal surface is deeply concave for articulation with the trapezoid bone; and is irregularly faceted for articulation with the trapezium, while the ulnar side articulates with the third metacarpal bone, and at the same time is produced upward and inward to articulate by a small surface with the os magnum.

The third metacarpal bone is a little smaller than the preceding. The proximal surface is triangular, with the apex of the figure truncated and directed toward the palmar surface. It is somewhat oblique, and articulates with the os magnum. At the dorsal surface on the radial border a small process projects upward. The radial border presents a single facet for the second metacarpal bone, and the ulnar has two facets for the fourth metacarpal.

The fourth metacarpal bone is yet smaller than the third. Its proximal extremity presents two facets; one of these, the larger, articulates with the cuneiform bone, while the other is reserved for the os magnum. The radial border yields two facets for articulation with the third metacarpal, while the facet on the ulnar border is single for articulation with the fifth metacarpal bone. The axis of the proximal extremity may be deflected a little to the ulnar side of the axis of the shaft.

The fifth metacarpal bone is more cylindrical than the others of the series. The dorsal surface is marked by a faint oblique ridge, to which are attached, at its radial side, the fourth Dorsal Interosseous muscle, and, at its ulnar side, the tendon of the Extensor Carpi Ulnaris muscle. The proximal extremity presents a wide, saddle-shaped surface for articulation with the unciform bone. A single facet is seen at the lateral side of the end of the bone, while the ulnar side is free.

SYNOPTICAL TABLE OF THE METACARPAL BONES.

Proximal end with single facet, having a smooth, rounded dorsal border	First and fifth.
Shallow groove running transversely, no facet on either side	First.
" " " " vertically, facet on median side	Fifth.
Proximal end with multiple facets, and uneven dorsal border	Second, third, and fourth.
Palmar border acuminate. Three proximal and two median facets, dorsal border with central notch	Second.
" " truncate	Third and fourth.
One proximal with two median and two lateral facets; dorsal border without notch, but having a large lateral process	Third.
One proximal, two lateral, and one median facet; dorsal border with neither notch nor process	Fourth.

PHALANGES.

The phalanges (Plate XXX.) constitute the bony framework of the fingers. They are fourteen in number: three to each of the fingers and two to the thumb. The general form of a phalanx is that of a semi-cylinder, the convexity of which is dorsal and the concavity palmar. The proximal end is somewhat larger than the distal. The borders are compressed, and marked on the palmar edges by ridges for the insertion of the tendons of the flexors of the fingers. The phalanges of the first row have their distal surfaces compressed from the dorsal to the palmar aspect, and form a series of narrow, rounded facets (most apparent on the palmar side) for articulation with the second row of bones. The median and lateral borders are each marked with a circular depression, to give attachment to the lateral ligaments. The proximal facet is circular and concave for the reception of the head of the corresponding metacarpal bone, and is marked by two tubercles, the inner of which is commonly the larger.—The phalanges of the second row present, proximally, two small concave facets, separated by a crest ranging from the palmar to the dorsal surface, for articulation with the distal surface of the first phalanx. Upon the sides are two tubercles for the insertion of the lateral ligaments. The first phalanx of the thumb, answering to the second of the other fingers, is distinguished by a body which is without tendinous impressions, and by borders which are smooth and simple; of these the ulnar border is more concave than the radial. The distal surface is not marked by a crest, and the tubercle on the radial side of the articular surface is more pronounced than that on the ulnar. The phalanges of the third row (ungual phalanges) diminish abruptly from the proximal surface forward.

The palmar surfaces are flat, and marked in advance of the distal end by wide expansions for the insertion of the tendons of the Flexor Profundus Digitorum. The crest on the proximal surface is less pronounced than on the phalanges of the second row. The free extremity is rounded and elevated, much roughened, and is marked on the palmar surface by a triangular notch. It serves to support the pulp of the finger tip. The sides of the palmar rugosity may be extended backward as little spines. The terminal phalanx of the thumb is relatively larger than the others. It is markedly asymmetrical, the median border being shorter and more concave than the lateral.

The Sesamoid Bones.—The sesamoid bones are rounded and seed-like in appearance, and are placed in the tendons of the various muscles of the hand at the side of the metacarpo-phalangeal joints. They are best developed at the thumb, where they are lodged in the tendons of the Flexor Brevis Pollicis, the Adductor Pollicis, and the Abductor Pollicis muscles. Similar structures are also found in the tendons of the muscle of the index and little fingers.

For remarks concerning the sesamoid bones see the general considerations of the muscles.

Development.—Each metacarpal bone and phalanx arises from two centres of ossification—one for the shaft or main portion, and one for an epiphysis. In all the metacarpal bones, excepting the first, the epiphyseal centre lies to the distal end of the shaft, but in the first it lies to the proximal end. In the phalanges the epiphyses are without exception proximately disposed. The nuclei of the shafts first appear in the eighth or ninth week; those of the epiphyses from the third to the fifth year. Development is complete at about the twentieth year.

THE BONES OF THE INFERIOR EXTREMITY.

The bones composing the inferior extremity are the innominate bone, the femur, the tibia, the fibula, the tarsus, the metatarsus, the phalanges, and the sesamoid bones—including the patella.

THE INNOMINATE BONE.

The innominate (pelvic, hip, haunch bone) (Plates XXXI., XXXII.) is the largest of the flat bones. It articulates with the sacrum and with the corresponding bone of the opposite side. While forming part of the framework of the trunk, it is included among the bones of the lower extremity. The two innominate bones articulate with the sacrum and the coccyx, and with them make up the *pelvis*.

The innominate bone is subdivided into three distinct portions, viz., the ilium, the pubis, and the ischium,—which are so disposed as to form two expanded, irregular plates, arranged end to end and connected by a narrow *isthmus*. The *upper plate*, which may also receive the name of the *iliac plate*, is flattened from within outward; while the *lower plate*, which may also receive the name of the *ischio-pubic* plate, is flattened from before backward. Intermediate in position to the above plates is the *acetabulum*.

Before describing the bone as a whole, the following brief account of the three component parts will be given.

The *ilium* constitutes the upper plate. In a strict morphological sense, it also includes part of the acetabulum, but for practical purposes it is sufficient to limit it inferiorly at the isthmus. The *pubis* forms the anterior portion of the ischio-pubic plate, and presents a compressed V-shaped figure,—the re-entering angle of which forms the *body*, the upper branch the *horizontal ramus*, and the lower branch the *descending ramus* of the pubis. The *ischium* comprises the posterior part of the ischio-pubic plate. It is more massive than either of the others, and presents in common with the pubis a V-shaped figure whose posterior prismoidal limb forms the *body*, and the anterior flattened part the *ascending ramus*.

A description of the innominate bone includes a lateral and a median surface; four borders; and the obturator foramen.

The *lateral surface* (outer, femoral, external) is more irregular than the median, and is divided into (*a*) the dorsum of the ilium, (*b*) the region of the acetabulum, and (*c*) the lateral surface of the ischio-pubic portion.

(*a*) *The dorsum of the ilium.*—The dorsum of the ilium is a broad, undulating surface that is covered in the undissected subject with the Gluteal and the Tensor Vaginæ Femoris muscles. It is concave at the anterior border, convex on a line with the posterior lip of the acetabulum, again concave for the greater part of the remaining surface, but is convex near the posterior border. Each of these sinuosities answers to some points of anatomical limitation. Thus, the first concavity answers to the origin of the Tensor Vaginæ Femoris, and in part to the surface of origin of the Gluteus Minimus. The first convexity answers to the begin-

ning of the surface of origin of the Gluteus Medius; the large second concavity is entirely occupied by the same muscle; the small second convexity is much roughened for the origin of the iliac fibres of the Gluteus Maximus muscle.—The dorsum is crossed by three faint lines, the superior, the middle, and the inferior, curved lines. The *superior curved line* is in common with the superior iliac border the greater part of its length, but is distinct in a nearly vertical position on the dorsum at the posterior convexity, where it separates the Gluteus Maximus from the Gluteus Medius muscles. The *middle curved line* is well marked anteriorly at the first dorsal convexity, and arching backward ends at the great sciatic notch. It is composed of the lower ends of the oblique rugosities for the origin of the Gluteus Medius muscle. The *inferior semicircular line* begins at the notch above the anterior inferior spinous process, and arches backward nearly concentric to the upper border of the acetabulum; it answers to the lower border of the Gluteus Medius muscle. Along the posterior border of the iliac portion are seen two processes, the *posterior superior spinous process*, and the *posterior inferior spinous process;* these are separated by a faint emargination.

(*b*) *The region of the acetabulum.*—The *acetabulum* (cotyloid cavity, socket for the head of the femur) lies below the narrowed portion of the hip bone (isthmus), and is directed downward, forward, and outward. It is formed by the junction of the main divisions of the bone in such a manner that two-fifths of its area is derived from the ischium, less than two-fifths from the ilium, and nearly one-fifth from the pubis. Nearly circular in shape the acetabulum is for the most part occupied by a C-shaped articular surface. The space between the ends of the curve of this figure is depressed, and directed downward and forward to form the basal and, at the lower and the inner lip, the shallowest part of the socket.

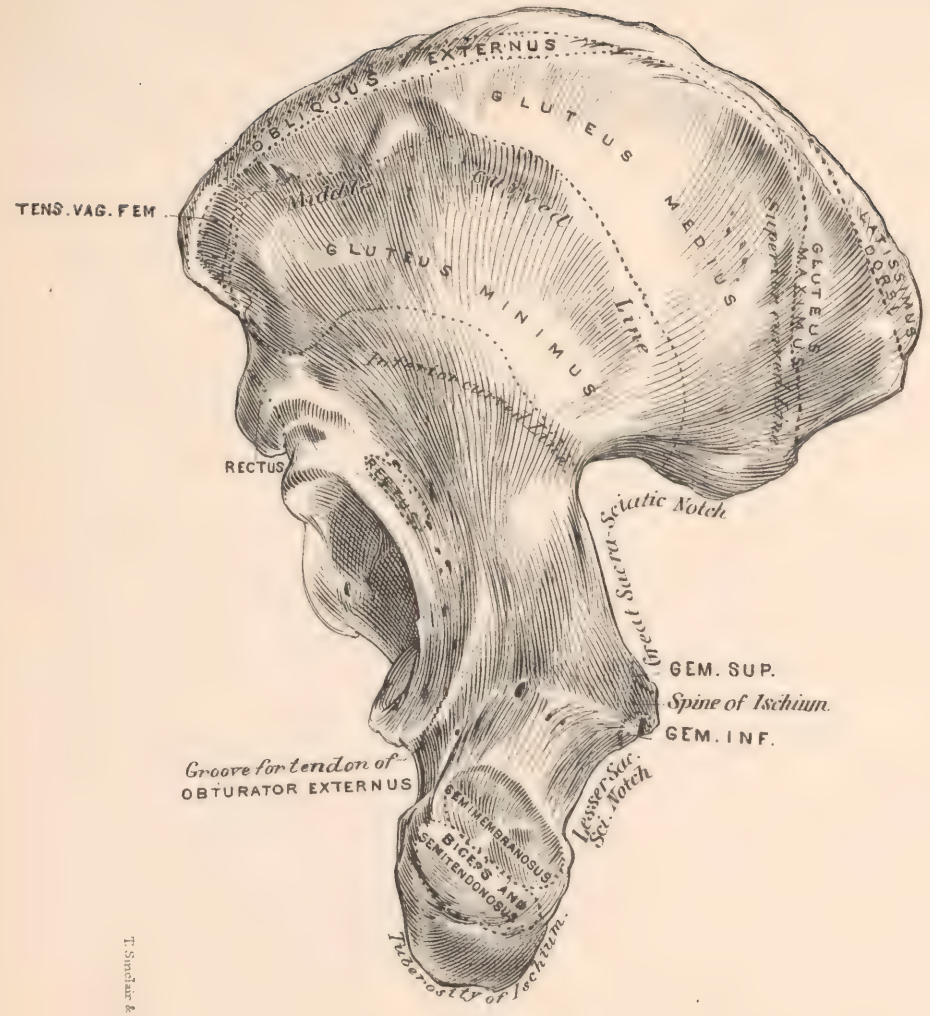
The articular surface is broadest and deepest on the ilium posteriorly where it forms in connection with the ischiatic portion the great *posterior lip;* narrowest on the ilium anteriorly where together with the pubic portion it forms the *anterior lip.* In the last named locality the curve is nearly continuous with the bottom of the socket, but on the ischium the curve corresponds to a rather bold elevation that forms in connection with the bottom the *cotyloid notch* (incisura). The articular surface in the unprepared bone is covered with cartilage, while the depression is filled with fat.—A short distance above the acetabulum a small transverse ridge is seen for the origin of the tendon of the Rectus Femoris muscle.

(*c*) *The lateral surface of the ischio-pubic portion.*—The lateral surface of the *body of the ischium* below the acetabulum exhibits a wide *groove* for the Obturator Externus muscle. On a level with this groove on the posterior margin lies the *spine of the ischium*, for the attachment of the lesser sacro-sciatic ligament and origin of the Superior and the Inferior Gemelli muscles. The ischium ends inferiorly in the *tuberosity*, which presents a broad flat surface looking outward and backward, and yields surfaces of origin for the Biceps, the Semi-Tendinosus, and the Semi-Membranosus muscles. The deep excavation on the posterior margin of the innominate bone between the posterior inferior process of the ilium and the spine of the ischium defines the *great sciatic notch*, which transmits the Pyriformis and the Obturator Internus muscles, the sciatic nerves, the gluteal artery and nerves, and the internal pudic vessels and nerves. The space between the spine of the ischium and the tuberosity has received the name of the *lesser sciatic notch.* The *ascending ramus of the ischium* narrows slightly to join the descending ramus of the pubis; an irregular line of nodules usually exists here to denote the line of sutural union. The lower margin of the ascending ramus is broad, continuous with the tuberosity, and affords a line of origin for the Adductor Magnus muscle. The lateral surface answering to the pubis is smooth on the body and on the greater portion of the *descending ramus*, except at the lower margin and near the symphyseal line, from which the Adductor Longus, the Adductor Brevis, and the Gracilis muscles arise. The massive *horizontal ramus of the pubis* broadens posteriorly towards the acetabulum, and merges into the anterior border of the innominate bone. It is grooved obliquely where it enters into the upper margin of the obturator foramen for the obturator vessels and nerves.

EXPLANATION OF PLATE XXXI.

Fig. 1. The innominate bone seen from the lateral aspect.
Fig. 2. The innominate bone seen from the median aspect.

For "Linea ileo-pectinea" read "Linea ilio-pectinæa."



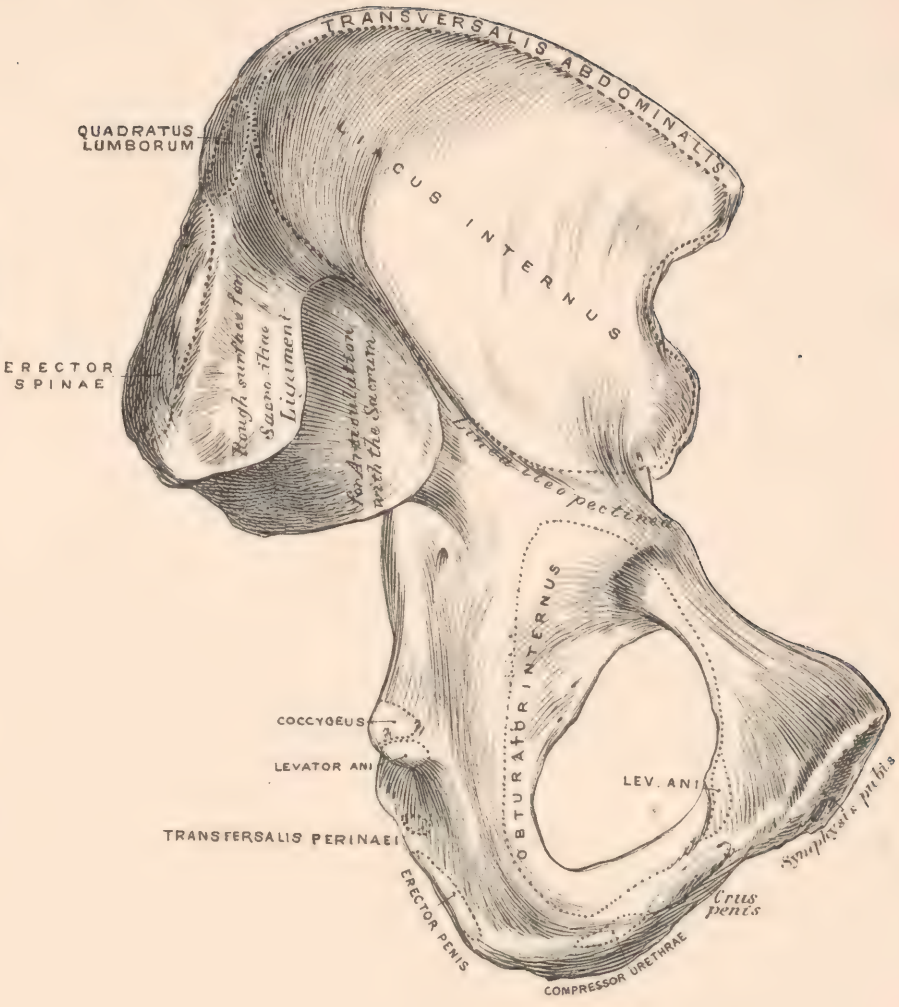


PLATE XXXI

T. Sinclair & Son Lith.

The *median surface* (pelvic surface) is for the most part divided into the iliac and ischio-pubic portions by a line,—the ilio-pectineal line,—(linea ilio-pectinæa), which extends obliquely downward and forward, from the anterior border of the surface for articulation with the sacrum to near the pubis.

The *iliac portion* is comprised of (*a*) the iliac fossa, (*b*) the facet for articulation with the sacrum, and (*c*) the iliac tuberosity.

(*a*) The *iliac fossa* is smooth and shallow, and occupies the anterior two-thirds of the ilium. It accommodates the Iliacus Internus muscle, and is limited behind by the upper half of the facet of articulation with the sacrum and the anterior edge of the iliac tuberosity, below by the ilio-pectinal line, and in front by the ilio-pubic junction, where a convexity—answering to the line of union between the ilium and the pubis—is seen, constituting the *eminentia ilio-pectinæa*, over which glides the Iliacus Internus muscle. (*b*) *The facet for articulation with the sacrum* (auricular facet) articulates with the lateral surface of the sacrum to effect the sacro-iliac junction. Its inferior posterior border forms the projection known as the *posterior inferior spinous process of the ilium.* (*c*) *The iliac tuberosity* is the rough convexity behind the last-named portion, and, when the bone is in articulation, constitutes part of the dorsal aspect of the trunk. It gives attachment to the sacro-iliac ligament, and in part origin to the Erector Spinæ muscle.

The *ischio-pubic* portion of the median surface is smooth, for the attachment of the Obturator Internus muscle. Under the name of the *ischial planes*, obstetricians indicate the space between the obturator foramen and the great sciatic notch. An imaginary line, extending from the ilio-pectineal eminence to the spine of the ischium, separates the *anterior* from the *posterior ischial* plane. At the lower margin of the ischio-pubic portion are located, in order from before backward, the surfaces of origin of the Coccygeus and of the Levator Ani muscles (a small portion of the origin of the muscle also lying in front of the obturator foramen), the Erector Penis, and the Compressor Urethræ muscles; it further affords attachment to the crus penis, and posteriorly to the great sacro-sciatic ligament. The surface answering to the body of the pubis assists in supporting the bladder. Along the median surface below the obturator foramen lie the internal pudic vessels and nerves.

The *borders* of the innominate bone are the superior, the inferior, the anterior, and the posterior.

The *superior border or the crest of the ilium* follows the convexities and concavities of the dorsum. It is thickest posteriorly where it corresponds to the iliac tuberosity, and thinnest directly in advance of the part last named. Corresponding to the position of the first dorsal convexity, the upper border is abruptly widened, and forms a prominence which is of much clinical significance, since it lies directly in a line with the great femoral trochanter, and serves as a convenient point from which distances can be measured, either to points about the hip, or to any part of the lower extremity. The superior border presents an outer lip, an inner lip, and an intermediate space. The *outer lip* gives origin to the Sartorius, the Tensor Vaginæ Femoris, the External Oblique muscle of the abdomen, the Latissimus Dorsi, the fascia lata, and the beginning of Poupart's ligament. The *inner lip* is designed for the origin of the Transversalis, the Quadratus Lumborum, and, in part, the Erector Spinæ muscle. The *intermediate space* is devoted to the origin in part of the Internal Oblique muscle.

The *inferior border* corresponds to the lower free edge of the descending ramus of the pubis and the lower and the lateral borders of the ischium. From the tuberosity forward to the angle of the pubis the inferior border comprises an *outer* and an *inner lip*, which have already been described under the head of the lower margins of the lateral and the median surfaces. The anterior third of the lower border is broad and oval, and constitutes the articular surface that forms in connection with the corresponding facet of the opposite bone the *symphysis pubis.*

The *anterior border* presents the following points in order from above downward. First, the *anterior superior spinous process*, from which and the lateral border of the crest the Sartorius muscle arises. Second, an emargination. Third, the *anterior inferior spinous process*, for the origin of the long head of the Rectus Femoris muscle, and attachment of the ilio-femoral fascicle of the capsular ligament. Fourth, the thin compressed anterior acetabular lip. Fifth, the broad triangular surface whose apex is directed forward and inward to form, at the junction of the anterior with the inferior borders, the *angle.* Sixth, the *pubic spine*, which is placed at the upper and anterior part of the body of the pubis, and is designed for the attachment of Poupart's ligament and the conjoined tendon. The interval between the spine and the angle gives origin to the External Oblique and the Pyramidalis muscles. Seventh, a surface for the origin of the Pectineus muscle.

The *posterior border* lies between the superior and

the inferior borders. It is thin and compressed in the iliac and acetabular portions, but is robust below. The posterior border embraces the posterior superior, and the posterior inferior spinous processes, the greater and the lesser sciatic notches, the ischiatic spine, and the ischiatic tuberosity. These have been described in connection with the lateral surface.

The *obturator foramen* is a large oval or triangular opening with sub-rounded angles, and is defined by borders derived from the pubis and the ischium. It is marked above by a faint prominence near the cotyloid notch, and below by another near the pubo-ischiatic junction. The foramen in life is occupied by a firm fibrous membrane which is covered laterally by the Obturator Externus muscle, and medianly by the Obturator Internus. It is pierced above by the obturator vessels and nerve.

Structure. — The greatest amount of compact tissue of the innominate bone is found in the curve of great sciatic notch and the bone extending thence beneath the spine of the ischium. The compact tissue is also well developed at the articular surface of the acetabulum and the dorsum of the ilium. The main bulk of the bone, however, is spongy, even the iliac and the ischiatic tuberosities being in great part composed of cancelli. The laminæ about the acetabulum are coarser than elsewhere, and exhibit radiating fibres which pass from the socket laterally, and which are intersected by others answering to the curvatures of this portion of the bone. The centre of the iliac fossa, which is the thinnest portion of the ilium, is, as a rule, translucent. In the negro the bone is massive, and the translucent appearance above mentioned is absent.

Development.—The innominate bone arises from eight centres of ossification. The first centre appears in the ilium at about the eighth week; the second, in the ischium at the third month; the third, in the pubis at the fifth month. The remaining centres are accessory to the above. The ilium exhibits two secondary points of ossification, the one for the crest, the other for the anterior inferior spinous process. The ischium retains one centre for the tuberosity; and the pubis also one for the symphyseal surface. The pubis and the ischium unite by their adjoined rami at about the eighth year. After the three main portions of the innominate bone have contributed to define the acetabulum, there still remains intermediate to their opposed surfaces at the bottom of the socket, a Y-shaped piece of cartilage, within which at about the eighth year, a nucleus of bone, retaining the shape of the cartilage, appears; this nucleus, while not serving as an epiphysis to any of the innominate segments, unites therewith about the twentieth year.

Remarks.—The innominate bone presents many varieties in the proportions and in the degrees of massiveness of the several parts composing it, while yielding but few distinct variations of minor character. Malgaigne invites attention to the fact that the projection of the first convexity of the dorsum of the ilium forms a dividing line of surgical significance. In fracture near the crest he finds the lines extending either from the portion in front of the convexity backward or from a point back of the convexity forward.—Osteophytes have been noted arising from the ilio-pectineal line to a sufficient height to serve as an exciting cause of uterine laceration during labor.[1]—The posterior lip is liable to be broken in dislocation of the head of the femur backward. Mr. H. Morris[2] believes that such fracture always occurs. This extreme position is controverted by Mr. F. S. Eve,[3] who, while accepting the fact that the lesion may occur, mentions three instances in which the acetabulum remained intact. It must be borne in mind that the dislocation is assumed to take place by such violence as to thrust the femur upward and backward.

In the living subject the crest of the ilium, and the lateral aspects of the ischium and the pubis can be in a measure discerned beneath the integument. In vaginal examinations with the finger the median surfaces of the pubis and the ischium can be outlined, while the spine of the ischium can be recognized with distinctness.—The highest point of the ilium is about on the level of the spine of the fourth lumbar vertebra.—The anterior superior spinous process is a little below the level of the promontory of the sacrum.

THE PELVIS.

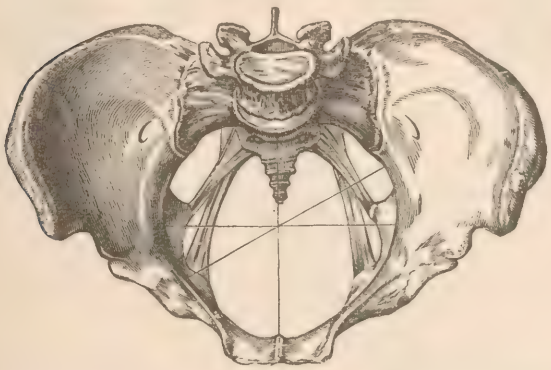
The pelvis (Fig. 1, Plate XXXII.) is the figure resulting from the union of the innominate bones with the sacrum and the coccyx. The artificial pelvis closely resembles the ligamentous, the most important distinction lying in the inferio-lateral portion, where the great sciatic ligament modifies the shape of the outlet of the osseous pelvis.

[1] New York Medical Journal, xi. 424.
[2] Med.-Chir. Trans., lx. 161.
[3] Med.-Chir. Trans., lxii. 51.

The pelvis receives its name from its rude resemblance to a basin. The brim of the basin must be considered as broken in front and behind; the latter opening, however, is in part occupied by the last lumbar vertebra.

The pelvis is divided by the ilio-pectineal line, and by the portions answering to the production of this line backward upon the sacrum, and forward upon the pubis, into the *true* and the *false* pelvis. The *false pelvis* (great pelvis) is in connection with the wall of the abdomen, which it aids to support; it is concave for the accommodation in part of the intestinal coil, and for the ovaries and the beginning of the Fallopian tubes in the female. The *true pelvis* (lesser pelvis) accommodates the internal organs of generation, the rectum, and in part the bladder. It is closed inferiorly by the perineum. The superior outlet of the true pelvis is called the *brim*, or the *superior strait*. Its figure is cardiform, the base answering to the promontory of the sacrum, the sides and the apex to the ilio-pectineal line. The inferior outlet is called the *inferior strait* or *outlet*. It is of an irregular outline. In front it answers to the triangular space defined by the conjunction of the ascending limb of the ischium and the descending limb of the pubis on each side of the symphysis pubis; at the sides it answers to the double sinuate line, extending from the tuberosity of the ischium to the sacrum. As already mentioned, the great sacro-sciatic ligament defines the inferior strait laterally in the ligamentous pelvis. The walls of the true pelvis are straight and smooth at the sides and at the back, and concave at the back and the front.

Fig. 71.



The pelvis seen from above, showing the position of the sagittal, frontal, and oblique diameters.

The Diameters of the Pelvis. (Fig. 71.)—The importance of a knowledge of the pelvis in connection with the science of obstetrics has led observers to carefully define its diameters. These will be presented in the following order:—

The conjugate diameter (antero-posterior, sagittal) of Nägele is a line drawn from the promontory of the sacrum to the superior margin of the symphysis pubis. It measures at the

Superior strait	$4\frac{1}{2}$ inches.
Cavity	$5\frac{1}{4}$ "
Inferior strait	5 "

The transverse diameter is a line drawn between the acetabula, as follows:—

Superior strait	$5\frac{1}{4}$ inches.
Cavity	$4\frac{3}{4}$–5 "
Inferior strait	4–$4\frac{3}{4}$ "

The following are the oblique diameters:—

Superior strait	5 inches.
Cavity	$5\frac{1}{4}$ "
Inferior straight . . .	$4\frac{3}{4}$ "

The pelvis not being exactly symmetrical, the right oblique diameter is somewhat shorter than the left.

Hermann Meyer describes a diameter named by him the *normal conjugate*. This line passes from the middle of the anterior surface of the third sacral vertebra to the upper border of the symphysis pubis. It is accepted as a more constant measurement than the conjugate, since it is not subject to material variation from the position of the pelvis or from the vertebral column. Meyer recommends in order to make satisfactory measurements of the pelvis that the observer place the anterior superior spinous process of the ilium and the spine of the pubis on the same vertical line, the body to be erect, as in the act of standing, and the limbs to be neither abducted nor adducted.

The most important of the external measurements of the pelvis are the following:—

Between the anterior superior spinous processes, 10 inches; between the central points of the crests of the ilia, 10 inches; between the spinous process of the last lumbar vertebra and the upper border of the symphysis pubis (external conjugate), 7 inches.

The pelvis presents some striking *sex distinctions*. Thus the bones of the female pelvis (Fig. 72) are lighter in structure than are those of the male; the true pelvis is wide and short, and possesses a cylindrical figure, which, in the child-bearing woman, is so modified as to be slightly increased in its transverse over its antero-posterior diameter. In the male (fig. 1, Plate XXXII.), the true pelvis is narrow and high, and the figure is somewhat ovate from before back-

ward. In the female the sub-pubic arch is wide and rounded at the symphysis, and forms an angle of about 90° to 100°; in the male the arch is angulated, and forms an angle of from 70° to 75°; in this sex the obturator foramen is also of a triangular figure.

Fig. 72.



The female pelvis.

Race distinctions can also be determined as well as those of sex. In the negro the transverse diameter

Fig. 73.

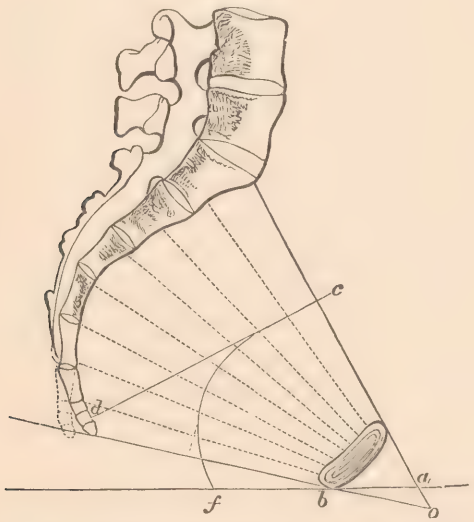


Diagram showing the inclination and axis of the true pelvis.

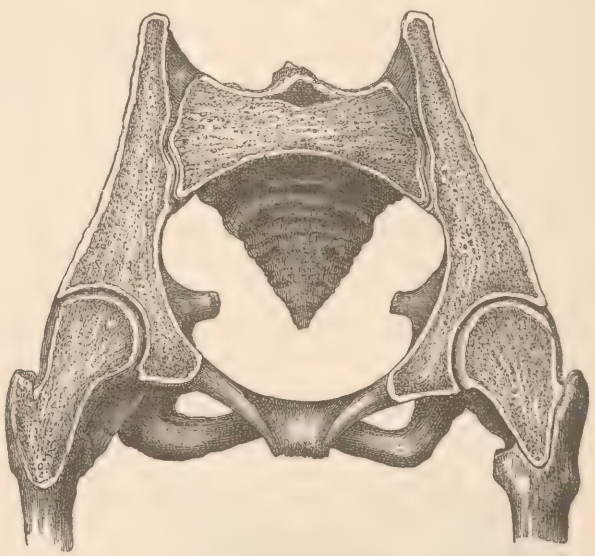
is less than in the white. The race distinctions of the pelvis have been made the subject of elaborate study by Mr. J. G. Garson.[1]

[1] Journal of Anatomy and Physiol., vol. xvi., Part I., 1881, 106 (figs.).

The *axis of the pelvis* is the sum of the lines uniting the centres of geometrical planes defined within the cavity of the true pelvis. This has been described as an irregular parabola. Considered as representing the line of descent of the body of the child during delivery the pelvic axis, as above defined, is approximately true only, since the pelvis, considered as a ligamentous or an artificial structure, retains, to an imperfect degree, the diameters of the inferior strait.

Mechanism of the Pelvis.—The pelvis is sustained in its relation to the trunk by the sacro-lumbar articulation, and with the lower extremity by the hip-joint. It is inclined slightly downward and forward, so that the plane of the superior strait assumes to a horizontal plane an angle of 55° to 65°. The exact degree of angulation present is determined by the amount of flexure in the lumbar vertebræ. The bones of the pelvis are not immovably fixed, but permit a moderate amount of motion to occur normally between one another.

Fig. 74.



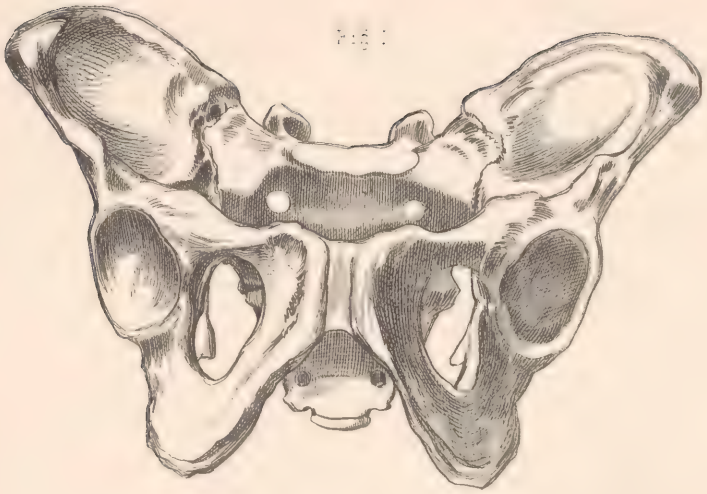
Section of pelvis showing the suspensory action of the sacro-iliac ligaments.

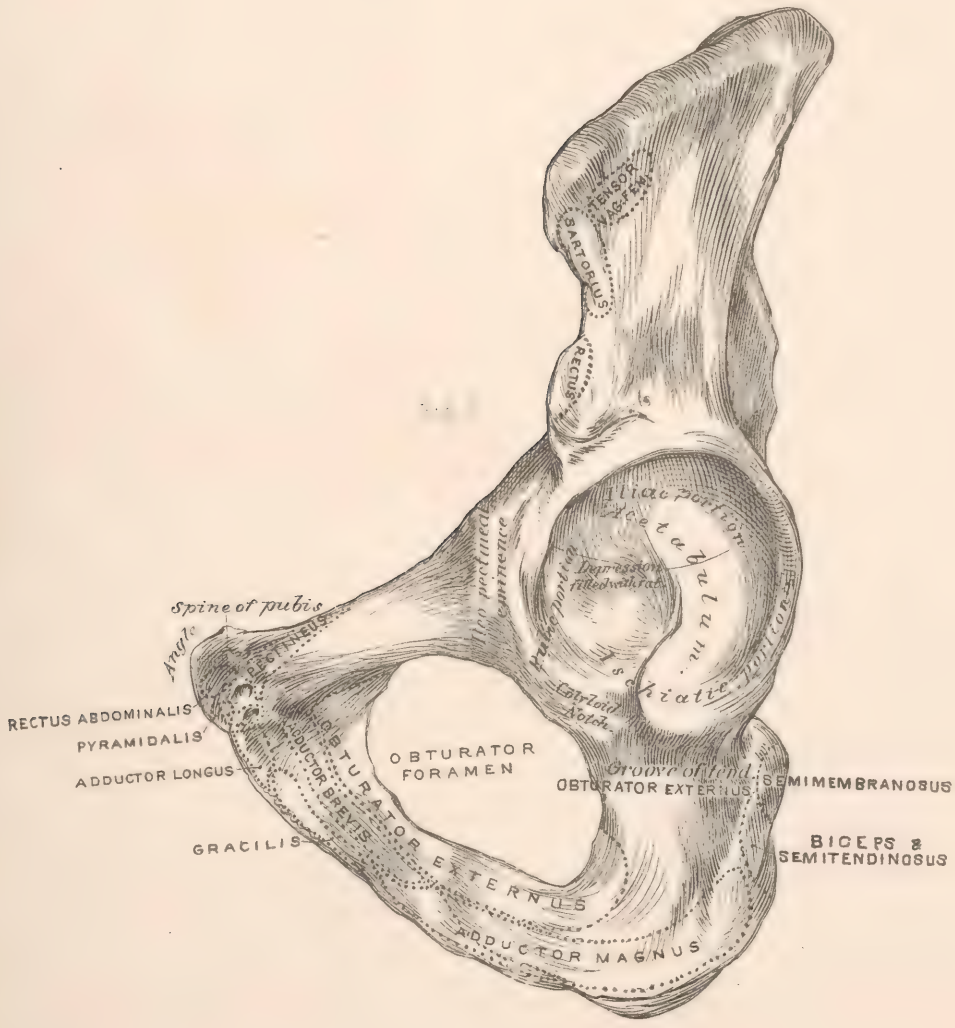
While sustaining the weight of the body, the sacrum, being broader behind than in front, would slip forward, if the motion were not checked by the stout ligaments uniting it with the innominate bone. The

EXPLANATION OF PLATE XXXII.

Fig. 1. The male pelvis seen from in front—the coccyx is absent.

Fig. 2. The innominate bone seen from in front.





W. Sinclair & Son, lith.

posterior of these ligaments, while thus checking the movement downward, will cause a slight degree of motion to take place at the symphysis. The latter, therefore, bears a direct relation to the amount of pressure forward of the sacrum against and between the innominate bones.—The lower part of the sacrum is so firmly fixed to the hip-bones by the sacro-sciatic ligaments (*i. e.*, on a plane below that of the symphysis pubis) as not to permit of motion. The pelvis when deformed, as in rickets, exhibits the greatest degree of deformity at and above the symphysis,—a result, it is thought, of the difference of effect of sacral pressure upon the innominate bone at and above the pubis, as contrasted with pressure below this bone.

In standing, the weight of the trunk rests upon the inferior extremities at the acetabula, and upon lines extending thence to the sacrum. The arch defined by connecting these lines has received the name of the *cotylo-sacral arch.* The line extending from the acetabula round the anterior surface of the true pelvis has received the name of the *cotylo-pubic tie.* In sitting, the weight of the body is borne by the tuberosities of the ischia, and is thence transmitted by arched lines to the sacrum. The sum of these lines has received the name of the *ischio-sacral arch*, and the line extending thence to the pubis the name of the *ischio-pubic tie.*[1]

THE FEMUR.

The femur or thigh-bone (Plate XXXIII.) is at once the longest and the largest bone in the body. It articulates above with the innominate bone and below with the tibia and the patella. When the lower extremity of the femur is placed with the condyles resting on the same plane, as in articulation, the axis of the shaft is oblique to a line dropped through the centre of the trunk.

The bone is divided into a shaft and two extremities.

The *shaft* is massive, compact, moderately curved upon itself from above downward, and twisted at its upper third. It presents in front and at the sides convex surfaces; of these the posterior is roughened above and ridged for muscular attachments, but is flat below where it enters into the popliteal space. Cylindroid or prismatic, with rounded angles at the middle third, the shaft is compressed, widened, and irregular both at the upper and at the lower thirds. —The *middle third of the shaft* is smooth in front, and narrowed behind to form a prominent ridge called the *linea aspera*, which presents for examination two lips and an intermediate space. The *lateral* (outer) *lip*, the more prominent of the two, receives the insertion of the central portion of the Vastus Externus; the *median* (inner) lip receives the corresponding part of the Vastus Internus; the *intermediate space* is occupied by the insertion in part of the Adductor Magnus muscle.—The *upper third of the shaft*, as already mentioned, appears to be slightly twisted upon the lower two-thirds. It is robust and subcylindrical, and presents a smooth anterior surface, somewhat flattened, and a rough posterior surface, upon which is a ridge continuous with the linea aspera. The lateral lip of this ridge is designed for the insertion of the Vastus Externus, and is directed nearly vertically upward to the lateral aspect of the base of the lesser trochanter. Still further to the lateral side of this line, namely at a point about two inches below the upper end of the shaft, is seen a deep narrow depression for the insertion of the Gluteus Maximus. The continuation of the median lip becomes, as it appears upon the median surface of the bone, the *spiral line*, which winds upward and inward round the lesser trochanter to the front of the shaft, where it ends in the *tubercle*, a rounded prominence situated at the anterior border of the great trochanter. The lower part of the spiral line in front of the lesser trochanter receives the insertion of the Pectineus muscle. W. Roger Williams[1] proposes the name of *inferior cervical tubercle* for a moderate elevation at the middle of the spiral line to which the Vastus Internus muscle effects important attachments. As distinguished from this the same writer calls the tubercle at the top of the spiral line the *superior cervical tubercle.* Above, the spiral line gives origin to the Vastus Internus muscle, and in front of the femur to the Cruræus. In the space defined by the lines above described are inserted the Adductor Longus and the Adductor Brevis muscles.—The *lower third of the shaft* is much broader than the upper, and is marked laterally and behind by the lines of the linea aspera as they pass to the condyles, the external of the two lines being the more prominent. The median line near its point of separation from the linea aspera is interrupted by the femoral artery as it winds round the femur to become the popliteal. Upon this line above the internal condyles is a minute spur-like *tubercle* corresponding in position to the highest point of the patellar groove as well as to the junction of the shaft with the epiphysis. It is designed for the insertion of the long tendon of the Adductor Mag-

[1] John Wood, art. Pelvis, Cyclopædia of Anatomy and Physiology (Supplement), 1859.

[1] Journ. Anat. and Phys. 1879.

nus muscle. The shaft is nourished by a branch of the femoral artery which enters a *canal* situated about the junction of the middle and the upper third of the shaft, and is directed upward.

The *upper extremity of the femur* presents for examination the head, the neck, the great trochanter, and the lesser trochanter.

The *head* is large and rounded, and enters into the construction of the hip-joint. It corresponds in position to a vertical line produced upward from the inner condyle. Describing nearly two-thirds of a sphere, the head presents a larger articular surface above than below the transverse plane, and projects over the neck more sharply below than above. At the lateral margin the head is continuous with the front of the neck, and extends thereon a few lines beyond the general articular surface. A little below and behind the centre of the head is a shallow circular *depression* for the attachment of the ligamentum teres. Elsewhere the head is separated from the neck by a shallow groove. With the exception of the depression for the ligamentum teres the head of the femur is covered with cartilage in the living subject.

The *neck* is a broad process of bone directed obliquely upward and inward from the upper end of the shaft at an angle of about 130°. Compressed from before backward, its anterior part is much flatter than the posterior, and presents, as a rule, a long narrow oblique border below, and a straight rounded more horizontal border above, which is perforated with numerous venous foramina. The neck is marked in front near the articular surface by a faint depression, which is often cribriform in appearance, and may receive the name of the *cervical fossa*. The neck is limited below by the inter-trochanteric line, and in front by the spiral line. A number of small *nutritious foramina* are seen on the hinder aspect of the neck at its base.

The *great trochanter* (trochanter major) is a large process continuous with the shaft and inclined to its lateral side. It lies on a lower level than the head, namely about three-quarters of an inch, and when the femur is in articulation it is nearly on a level with the spine of the pubis. It is irregularly quadrilateral in shape, the posterior border being imperfect. The *anterior border* is limited about the position of the tubercle at the point where the Vastus Externus and the Gluteus Maximus muscles meet. The *superior border* is rounded, and serves behind at its free portion for the insertion of the Pyriformis, and in part, where it is continuous with the neck, for the insertion of the Obturator Internus. At the angle of junction of the superior and the anterior borders, the Gluteus Minimus is inserted, while the corresponding angle between the superior and the posterior borders forms a prominent *process*, which lies about on a level with the depression for the ligamentum teres. The *inferior border* is obscure, and answers to the line of union of the trochanteric epiphysis with the shaft. The *anterior surface* of the great trochanter is flat. The *posterior surface* is large and convex, and is crossed obliquely from above downward and forward and from within outward by a faint *ridge* which limits inferiorly the space for the insertion of the Gluteus Medius muscle. Below this ridge is a smooth surface (covered by a bursa in the subject) over which glides the Gluteus Maximus. The *median surface* is depressed to form the *digital fossa*, into which is inserted the tendon of the Obturator Externus, and, in part, that of the Obturator Internus.

The *lesser trochanter* (trochanter minor) is designed to receive the insertion of the conjoined tendon of the Iliacus Internus and the Psoas Magnus muscles. It is situated below and behind the base of the neck, and is directed inward and backward. It is somewhat nipple-shaped, and presents a posterior surface which is smooth, and on the plane of the general posterior aspect of the bone at this point. The anterior, superior, and inferior surfaces are free; the last serve to support the process from below. The summit of the lesser trochanter is, in the living subject, covered by a bursa over which glides the Quadratus Femoris muscle.

Under the name of the *intertrochanteric line* is included a prominent ridge extending obliquely down-

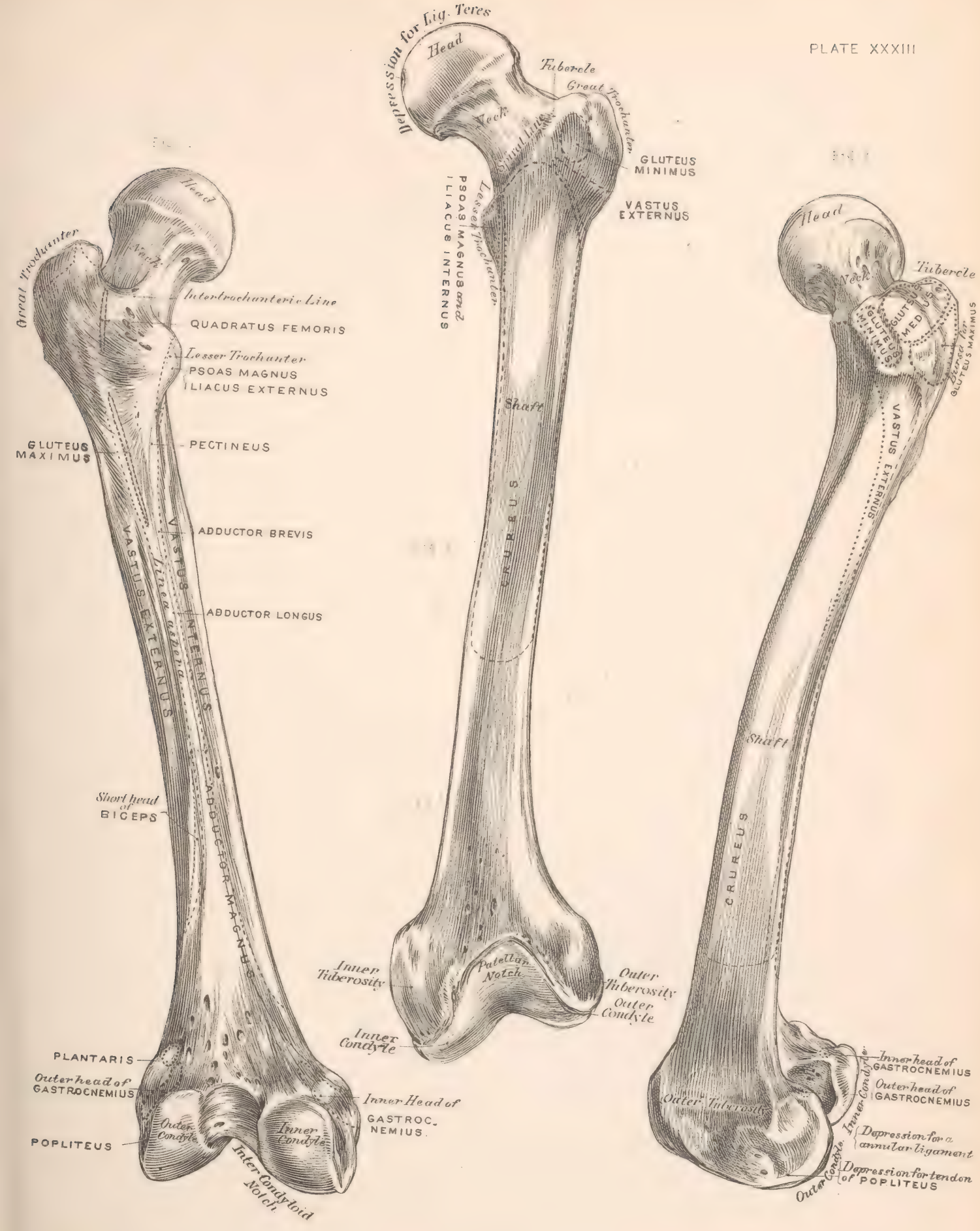
EXPLANATION OF PLATE XXXIII.

Fig. 1. The femur seen from behind in natural position.

Fig. 2. The femur seen from in front in conventional position.

Fig. 3. The femur seen from the lateral aspect in the natural position.

The words "Depression for annular ligament" should be omitted.


Great trochanter
Head
Neck
Intertrochanteric Line
QUADRATUS FEMORIS
Lesser Trochanter
PSOAS MAGNUS
ILIACUS EXTERNUS
GLUTEUS MAXIMUS
PECTINEUS
ADDUCTOR BREVIS
ADDUCTOR LONGUS
VASTUS EXTERNUS
VASTUS INTERNUS
Linea aspera
ADDUCTOR MAGNUS
Short head of BICEPS
PLANTARIS
Outer head of GASTROCNEMIUS
POPLITEUS
Outer Condyle
Inner Condyle
Inter condyloid Notch
Inner Head of GASTROC. NEMIUS
Depression for Lig. Teres
Head
Tubercle
Great Trochanter
Neck
Spiral line
GLUTEUS MINIMUS
VASTUS EXTERNUS
Lesser Trochanter
PSOAS MAGNUS and ILIACUS INTERNUS
Shaft
CRUREUS
Inner Tuberosity
Patellar Notch
Outer Tuberosity
Outer Condyle
Inner Condyle
Head
Tubercle
Neck
GLUTEUS MINIMUS
GLUTEUS MEDIUS
Bursa for GLUTEUS MAXIMUS
VASTUS EXTERNUS
Shaft
CRUREUS
Inner head of GASTROCNEMIUS
Outer head of GASTROCNEMIUS
Outer Tuberosity
Inner Condyle
Depression for a annular ligament
Depression for tendon of POPLITEUS
Outer Condyle

ward and inward, and joining the inferior border of the great trochanter with the lesser trochanter. It limits the base of the neck. At a right angle to the above-mentioned line the Quadratus Femoris muscle is inserted.

The *lower extremity* of the femur is broad, and transversely flattened, and is wider behind than in front. It presents for examination an external (lateral) and an inner (median) condyle, together with the intercondyloid notch and the patellar groove.—The *external condyle* yields a lateral, nearly flat border, which is continuous with the lateral surface of the shaft. The articular surface is convex and broad, but narrowed slightly as it approaches the posterior surface, where it terminates in a horizontal border. Above it lies a faint *impression* for the origin of the lateral (outer) head of the Gastrocnemius muscle. The lateral surface presents a rounded eminence called the *external tuberosity*. Below this the surface is marked by a pronounced *depression* for the external lateral ligament, and the *groove* for the Popliteus muscle.—The *internal condyle* is inclined obliquely inward and slightly downward, and broadens at its posterior oblique border. Above is a *depression* for the origin of the median (inner) head of the Gastrocnemius muscle and the *internal tuberosity* (corresponding in position with the eminence on the external condyle) for the attachment of the internal lateral ligament.

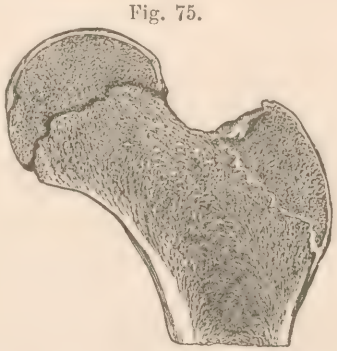
When the isolated bone is placed in a vertical position, the inner condyle descends below the level of the outer; this effect disappears when the bone is placed as in articulation.

Posteriorly the condyles are separated by a deep notch — the *intercondyloid notch* — whose opposed lateral surfaces and base are concave for the attachment of the crucial ligaments.—The condyles are continuous anteriorly by means of a shallow, saddle-shaped surface, termed the *patellar groove*, whose deepest convexity lies on a level with the top of the inter-condyloid notch posteriorly, and whose greatest convexity lies to the outer side of this depression. The notch answers to the resting-place of the patella in the position of the thigh in extension. Above the patellar notch is a long, shallow excavation, covered in the fresh state with thick periosteum, and furnished with orifices for veins.

Structure.—The walls of the shaft are enormously thick, the median being somewhat the heavier. The *proximal end* of the bone exhibits five sets of lines in the spongy tissue, which are limited abruptly inferiorly at a little below the level of the trochanter minor, and thence extend through the upper portion of the bone. The *first* set are confined to the head, and, indeed, distinguish its epiphysis throughout life. The lines are arranged in close series, radiately to the curve of the articular surface. The line of junction with the neck is at times marked by a number of coarser interspaces than those seen elsewhere. The *second* set begin opposite the trochanter minor, and pass upward to the epiphyseal junction, which it for the most part occupies, as a cluster of straight, stout lamellæ. In some specimens these lines are so closely serried as to present the appearance of compact tissue. Toward the proximal end of the lower border they are weaker. The *third* set are coarse, and range from opposite the lesser trochanter down to the lower limit of the spongy area. They serve to faintly intersect the *fourth* set, which are the strongest and the best developed. These range curvilinearly from the lateral border of the line at and below the base of the great trochanter to the upper portion of the epiphyseal junction. Some of the stouter of these lines, as they range from the upper border of the neck toward its axis, may be continuous with the weak upper border, as described by H. C. Bigelow.[1] The *fifth* set are the loosely arranged and weak cancelli of the great trochanter.—The *distal end* of the bone is occupied by a set of stout, nearly vertical lines in the outer condyle, which pass thence to the outer side of the shaft, and a second much weaker and more oblique set in the inner condyle. A number of weak transverse lines intersect the foregoing at right angles.

Development.—The femur arises from five centres of ossification. The first appears in the shaft at about the fifth to the seventh week. The second appears in the condylar epiphysis at the ninth month of fœtal

Fig. 75.



A longitudinal section of the head and neck of the femur, showing the positions of the epiphyses for the head and the great trochanter.

[1] The Hip, p. 120.

life. The third appears in the head of the bone at the end of the first year. To these are added, as secondary ossifications, the centre for the great trochanter at the fourth year, and the centre for the lesser trochanter at the thirteenth year.

The lesser trochanter unites with the shaft at the seventeenth year; the great trochanter and the head of the femur a year later; the condylar epiphysis ossifies with the femur soon after the twentieth year.

Remarks.—The depression for the *ligamentum teres* varies greatly in size. Generally of a triangular form, it is often irregularly rounded, with swollen, everted lips; its size is greater, other things being equal, in young than in adult bones; and it is more acutely depressed in large massive specimens than in smaller and thinner ones. In the former, the lower lip is often thickened and thrown forward.—In certain specimens from females the depression is very shallow, and the foramina at the bottom are generally present. Sometimes reduced to one — often numerous and larger—they are well seen in young adult bones; but faintly marked, or entirely absent in oldish, or heavy massive ones. In arthritis, the depression is either entirely filled up, and even produced, or it is scooped out, and bears osteophytes upon its borders. The shape of the head varies.

The proximal end of the line of insertion of the Gluteus Maximus is often more pronounced than the remaining portion; when exaggerated in size, this prominence has received the name of the *third trochanter*, from the fact that it is analogous to a similar projection on the femur of some of the lower animals, such as the horse and the rhinoceros.—The epiphyseal line at the head lies within the embrace of the capsule. In some diseases of the femur, as, for example, inflammation at the head of the bone in coxalgia, the epiphysis may become detached.—The distal epiphysis may be detached by violence, and thereby simulate compound fracture of the lower third of the shaft.—An exostosis of the femur occasionally occurs by ossification of the tendinous insertion of the Adductor Magnus.—An exostosis from the posterior surface of the femur at its lower end has been known to rupture the popliteal artery and necessitate amputation of the thigh.[1]—An exostosis upon the inner side of the femur at the middle third is supposed to be caused by the frequent pressure of the thigh against the side of the horse in riding, and has from this circumstance received the name of *dragoon's exostosis*. Necrosis of the femur is more frequent at the lower third of the shaft than elsewhere, particularly in the adolescent. This frequency is probably connected with the great vascularity of this portion of the bone during development.

[1] Boling, N. A. Med. Chir. Rev., 1857, 608.

THE TIBIA.

The tibia (figs. 1, 2, 3, Plate XXXIV.) is the largest of the long bones, the femur alone excepted. The shaft is for the most part prismoidal in form, narrower at the lower third than elsewhere, and presents a well-marked irregular expansion above to constitute the upper, and a smaller but decided increase of width below to constitute the lower extremity. The limits of the extremities are not, however, accurately distinguished from those of the shaft.

The tibia articulates by its lateral surfaces with the fibula at both the upper and the lower end. Above, the tibia is in articulation with the femur, and below, with the astragalus.

The *upper extremity* is expanded and elongated transversely, so that the borders project beyond the shaft, the median projection being the larger of the two. Above are seen two articular facets, the *condyloid* (glenoid) *surfaces*, for the femoral condyles. Each of their surfaces is of an oval shape, the internal being the more elliptical of the two. Between them is seen the *spine* of the tibia placed nearer the posterior than the anterior margin of the bone, and presenting two lateral *tubercles*, each of which is continuous with the curve of its own articular surface,—the median *internal* tubercle being the larger. Between the spine and the anterior border on the one hand, and the spine and the posterior border on the other, are two rough triangular surfaces for ligamentous attachment; the posterior of these is the more oblique, and is designed for the attachment of the posterior crucial ligament; the anterior is for the attachment of the anterior crucial ligament and the semilunar cartilage. The lateral surfaces of the upper extremity of the bone form the *tuberosities*. These are smooth, convex prominences, the median being the larger, and marked behind by a depression for the middle division of the tendon of the Semimembranosus muscle. The lateral tuberosity is broader than the median, and is further distinguished by a flat rounded facet directed downward and backward for articulation with the facet on the head of the fibula. In front a *tubercle* is situated for the origin of the Tibialis Anticus muscle. Posteriorly the upper extremity is slightly depressed, and exhibits between the articular surfaces the *popliteal notch* (inter-

condyloid notch). Anteriorly lies a smooth triangular surface whose apex is directed downward, and whose base lies a little backward therefrom on a level with the articular facets. This space is furnished with numerous vascular foramina, and in life is covered with a thick cushion of tough fatty tissue. At the apex the surface is provided with the roughened *tubercle for the attachment of the ligamentum patellæ*. Immediately above the tubercle the bone is smooth for the accommodation of a bursa.

The *shaft* of the tibia is broad above, but gradually narrows at its lower third, from which point of narrowing it slightly increases in size to the lower extremity. It presents an anterior, a lateral, and a posterior surface, and three borders of the same name.

The *anterior surface* is smooth, and, for the most part, slightly convex. At its upper third it receives the aponeurosis made up of the expanded tendons of the Sartorius, the Gracilis, and the Semimembranosus muscles. The middle third is smooth and subcutaneous, and forms the "shin" of common language. The lower third is slightly depressed if not concave; it is in part subcutaneous, and in part covered by the tendons of the extensors of the toes.

The *lateral surface* is concave for the upper two-thirds, somewhat convex at the lower third. It is furnished throughout its entire length with a *ridge* for the attachment of the interosseous membrane. The ridge lies near the posterior border, if, indeed, for the lower two-thirds of its length it does not define it, and is especially well marked at the lower end of the shaft, where it is the frequent site of small, irregular outgrowths. In front of this ridge, at its upper part, is a broad, shallow depression for the origin of the Tibialis Anticus muscle.

The *posterior surface*, the least regular of the three, is flat above, where it is marked by an *oblique line* which passes from the upper and the outer border downward and inward to terminate at the median border of the shaft at the junction of the upper and the middle thirds. It serves for the origin of the Popliteus muscle. The surface above the oblique line is covered by the last-named muscle; that below the line, as far as the position of the downward-directed *nutrient foramen*, by the origin of the Soleus muscle. Passing thence down the middle third of the bone is a vertical *ridge* (becoming indistinct below) which serves to separate the origin of the Flexor Longus Digitorum from that of the Tibialis Posticus muscle.

Of the *borders* of the tibia, the *anterior* is prominent at its upper two-thirds (crest of the tibia), but rounded and inconspicuous at its lower third. It is slightly curved outward at its upper third. It separates the anterior from the lateral surfaces. The *lateral border* is rounded and faintly expressed below the external tuberosity by a rounded surface. At the lower extremity it is more compressed, and answers to the ridge for the interosseous membrane. It separates the lateral from the posterior surface. The *posterior border* is well developed at its lower two-thirds, and is continuous above with the oblique line. In the upper third the border is smooth and rounded. It separates the anterior from the posterior surface.

The *lower extremity* is subtriangular in form, presents a base directed downward, and is furnished with swollen borders before and behind that project beyond those of the distal *articular surface*. The *anterior border* is for the most part smooth, but provided near the articular surface with a rounded eminence for the attachment of the anterior tibiofibular ligament. The *posterior border* is slightly smaller, and projects a little further downward than the foregoing. It is marked by a deep oblique *groove* (overlying the posterior surface of the internal malleolus) for the tendons of the Tibialis Posticus and the Flexor Longus Digitorum muscles. A fainter and less constant groove lying to the lateral side of the foregoing is designed to accommodate the tendon of the Flexor Longus Pollicis muscle. The *lateral surface* of the lower extremity is concave, and presents a small facet for articulation with the fibula; the *median surface* projects downward as a robust process, wider behind than in front—to form the *internal malleolus*. The *under surface* of the malleolus is smooth for attachment of the deltoid ligament. The distal articular surface of the tibia is broad, triangular, with its base directed laterally, its apex medianly, at which point it is abruptly deflected downward to form the lateral surface of the internal malleolus.

STRUCTURE.—At the *proximal end* of the tibia are seen two sets of nearly vertical lines passing from the condylar surfaces downward to the sides of the shaft. In the space between these, weak interlacing oblique lines, as well as others that terminate upon the sides of the spine above and the median aspects of the condylar lines below, are detected. Arranged horizontally to both the foregoing are simple, nearly concave lines which are sparsely distributed below the articular surfaces, and are in a measure concentric therewith.

In some specimens the lines of the epiphysis can be easily distinguished from those of the shaft. All the lines on the median half are stouter than those on the lateral.

At the distal end substantially the same arrangement exists as in the radius and ulna. Langerhaus describes the cancelli as made of a series of lines arranged either vertically to the articular surface or slightly converging to it; they are intersected by weak transverse lines. The arrangement varies in detail in the internal malleolus, as contrasted with the proper axial articular surface of the bone. The details of the epiphysis are measurably distinct from those of the shaft.

DEVELOPMENT.—The tibia arises from three centres of ossification. One for the shaft, which appears at the fifth or seventh week. One for the upper epiphysis at the ninth month of fœtal life. One for the lower epiphysis at the second year. The last joins the shaft at the twentieth year, and the first at the twenty-fifth. The tubercle very rarely arises from a centre of ossification separate from the proximal epiphysis.

When the shaft of the tibia is much compressed from side to side, as occurs in some savage and primitive races of men, it receives the name of the flat or platecnemic tibia.—The upper articular surfaces are sometimes placed obliquely to the axis of the shaft in such wise as to present the median surface on a higher plane than the lateral. This disposition of parts is commonly if not always found in limbs in which the position of extreme flexion has been maintained for a long time.—In chronic rheumatoid arthritis the spaces behind and in front of the tibial spine are obliterated by new bony growths.

REMARKS.—Separation of the epiphysis of the distal[1] end of the tibia has been observed by R. W. Smith and R. Quain in lads sixteen and seventeen years of age. In this condition the internal malleolus will preserve its natural relations to the foot, but not to the leg or outer ankle. M. De Morgan[2] records a case of detachment of the tubercle of the tibia by muscular action in a boy of seventeen years. Deep-seated abscess of the bone is relatively frequent at about the junction of the upper portion of the bone with the shaft.—The tibia is liable to extraordinary deformation in rickets, owing to the fact that the resistance of the weight of the body is to a great degree transferred to it from the foot.—Exostoses may arise from the points of origin and insertion of muscles at the upper third of the bone.—From its peculiarly exposed situation, the anterior surface of the middle third of the shaft is a frequent seat of the changes incident to chronic ostitis and necrosis.

[1] British Med. Journ., Aug. 1867, 123.
[2] Med. Times and Gazette, 1853, 268.

THE FIBULA.

The fibula (figs. 4, 5, Plate XXXIV.) is a long slender bone placed to the outer side of the tibia with which it is in articulation at its two extremities. Below it joins the astragalus at the outer side. Its position as compared with that of the tibia is slightly oblique from above downward and forward. It is slightly twisted inferiorly. The inferior extremity is thus placed a little in advance of the upper, at the same time that the lower half is directed inward toward the tibia.

The fibula consists of a shaft and an upper and a lower extremity.

The *upper extremity* consists of a head, a neck, and a styloid process. The *head* is a rounded prominence exhibiting an oblique proximal surface directed downward and inward, and is distinguished by an oval *facet* (often inconspicuous) for articulation with the tibia. Laterally and posteriorly the head is subcutaneous in part. Along its free surface the Soleus and Peroneus Longus muscles arise. Behind the superior posterior tibio-fibular ligament is attached, and in front the superior anterior tibio-fibular ligament. The *neck* is a term conventionally applied to that portion of the shaft immediately below the head. Strictly speaking, it has no limitation. The *styloid process* of the fibula is directed proximally along the lateral side of the bone, and is designed for the attachment of the tendon of the Biceps muscle, and the short external lateral ligament of the knee-joint.

The *shaft* of the fibula is slender and more robust in the middle third than elsewhere. It is prismoidal and somewhat triangular in its upper two-thirds; irregularly lozenge-shaped in its middle third, and elliptical in its lower third. The shaft presents for examination three borders, three surfaces, and the ridge for the interosseous membrane. The *anterior border* extends from near the head to the lower third in a sharp, straight, well-defined line. As it approaches the lower third of the bone, it inclines outward and bifurcates, the inner branch of the bifurcation continuing as a straight line to the lower extremity, the outer diverging downward and outward to terminate on the outer surface of the external malleolus. The *external border* is more rounded than the anterior; it passes downward along the outer border to the lower third of the shaft, where it turns slightly backward to constitute the posterior border of the lower third. It

ends at the corresponding border of the external malleolus. The *internal border* is of less significance than the others. It is obscurely developed near the head; but about two inches below this part it assumes a linear appearance and continues hence to the lower third of the bone where it crosses the inner surface obliquely to terminate, as a rule, by joining *the ridge for the interosseous membrane.* This ridge begins near the head of the bone close to the inner side of the articular border, whence it continues downward along the inner surface to be lost above the articular surface of the external malleolus.—The *external surface* is concave at its upper two-thirds for the origin of the Peroneus Longus and the Peroneus Brevis muscles. It is smooth below and covered by the tendons of the same muscles. The *posterior surface* is flat for the origin of the Soleus muscle, and winds round the inner surface of the bone on its lower third, and is occasionally marked by a small *nutritious foramen* directed downward at about its middle third. The *internal surface* is divided by the ridge for the interosseous membrane into two narrow spaces, one lying between the ridge and the anterior border, yielding surfaces of origin for the Extensor Proprius Pollicis, the Extensor Communis Digitorum, and the Peroneus Tertius muscles, and the one lying between the ridge and the posterior border, wider and more depressed, designed for the origin of the Tibialis Posticus muscle.

The *lower extremity* answers to the lower twisted portion of the bone. It begins at the point of greatest lateral compression, namely, where the internal border joins the ridge for the interosseous membrane. Beyond, the narrow elliptical portion has received, from some English writers, the name of the neck. The inner side is rough and marked by an elongated triangular surface for the strong fibres of the interosseous membrane. The outer surface is convex and subcutaneous.

The lower extremity gradually increases in size as it approaches the corresponding extremity of the tibia where its distal end is called the *external malleolus.* Larger and more prominent than the internal malleolus, and, in articulation, placed a little posterior to it, the external malleolus resembles the lower third of the shaft, with which it is continuous in its wide lateral, and narrow antero-posterior surfaces. It is of a triangular shape, its antero-inferior border being somewhat angulated. The posterior border is thicker than the anterior, and is faintly grooved for the tendons of the Peroneus Longus and the Peroneus Brevis muscles. The *anterior surface* is convex and subcutaneous. The *median surface* presents a triangular articular facet, slightly convex from above downward for articulation with the astragalus, and at its upper portion with the tibia. Below and behind this facet is a roughened depression for the posterior fascicle of the external lateral ligament and the posterior fibres of the capsule. The summit is rounded for attachment of the middle fascicle of the external lateral ligament of the ankle-joint.

Structure.—In the proximal end the main lines of the cancelli radiate from the articular surface and are intersected by concave transverse lines. Substantially the same arrangement obtains at the distal end, where the radiating fibres are notably conspicuous, and where they pertain more to the surface of contact with the astragalus than with the tibia.

Development.—The fibula arises from three centres of ossification: One for the shaft which appears at the sixth week; one for the lower extremity which appears at the second year; and one for the upper extremity which appears at about the fourth year. The second named unites with the shaft at about the twentieth year, and the last at about the twenty-fifth.

Remarks.—The fibula and tibia when seen in articulation present some striking features of contrast. Thus the shaft of the tibia is turned slightly forward, while that of the fibula is turned backward and outward. The shaft of the tibia is prismoidal with the base directed backward; the shaft of the fibula is prismoidal with the base directed outward. The tibia extends proximally one inch beyond the fibula; the fibula extends distally one inch beyond the tibia. The lower third of the tibia is slightly compressed from before backward; the lower third of the fibula is greatly compressed laterally.

The most superficial parts of the fibula are the head and the lower third of the shaft including the malleolus.—The head of the fibula lies on a level with the tubercle for the Quadriceps Extensor tendon. This becomes a valuable point for reference in conditions where the head is concealed by swelling of the surrounding soft parts. The lower third of the shaft together with the malleolus can always be defined beneath the skin, and owing to its peculiarly exposed position is liable to fracture.

The place of insertion of the Biceps muscle sometimes forms a conspicuous rounded projection at the base of the styloid process.

The probable communication between the articular surface of the proximal end of the fibula and the knee-joint, as well as the proximity of important vessels

thereto, should be constantly borne in mind by the surgeon. It is asserted by Knox that an operation of Liston's for excision of this portion of the bone resulted in death from hemorrhage. Examples are on record of death from pyarthrosis following the same operation, as well as from the removal of tumors involving the head of the fibula.

In talipes varus the fibula may touch the calcaneum and effect a joint therewith. In atrophy of the peroneal muscles, notably that of the Peroneus Longus, the eminence of the external malleolus becomes unduly prominent.—Osteophytes are specially liable to form at the median margin of the shaft above the distal articular surface.

The mechanism of the deformity of fracture of both malleoli is, according to Dr. Gordon Buck,[1] as follows:

When both malleoli are fractured, the tibia tends to slide forward so that only the posterior half of the articular surface rests upon the articular surface of the astragalus. The dorsum of the foot is hereby shortened and the heel projects backward. The lower part of the leg presents a remarkable curve with its convexity forward. The same authority[2] describes a specimen of necrosis of the tibia, in a child twelve years of age, in which a sequestrum extended through the distal end of the tibia into the ankle-joint, which was anchylosed. The specimen was mainly interesting from the circumstance that the process of necrosis was not limited to the compact portion of the bone, but had fairly extended into the spongy portion.

THE PATELLA.

The patella (figs. 6, 7, Plate XXXIV.) or knee-cap is a sesamoid bone lodged in the tendon of the Quadriceps Extensor Cruris muscle. It is subcutaneous, and can be easily distinguished in the undissected subject. It is movable when the leg is extended, but fixed against the trochlea and external condyle of the femur when the leg is flexed. It is broader than long, sub-triangular in form with its thickened rugose base directed proximally to receive the tendon of the Quadriceps. The apex is in connection with the ligamentum patellæ.

The patella presents for examination an anterior and a posterior surface, and a median and a lateral border. The *anterior surface* is faintly convex in all directions, and is marked with linear striæ and grooves, as well as with a few nutritious foramina. The *posterior surface* is concave from above downward, and concavo-convex from side to side. It is covered with cartilage for articulation with the femur. A ridge-like eminence extends a little to the median side of the middle line downward and inward. The lateral facet is concave, and larger than the median, which is obscurely convex. The borders are slightly emarginated superiorly, but convex inferiorly. The apex of the bone projects downward to a distance equalling nearly one-fourth the length of the articular surface. The base of the patella is broader behind than in front. The lateral margin is thin and subtruncate; the median is evenly rounded.

Structure.—The patella, when sawn open from side to side, shows an evenly textured surface. The cancelli are small, save at the apex, where they are coarse and uneven.

Development.—The patella arises by a single centre of ossification, which appears at the third month.

Remarks.—The most important fact to be remembered in connection with the patella is its disposition to transverse fracture. This occurs either from muscular violence, or from falls upon the flexed knee when the patella is fixed against the patellar groove of the femur and the external condyle.

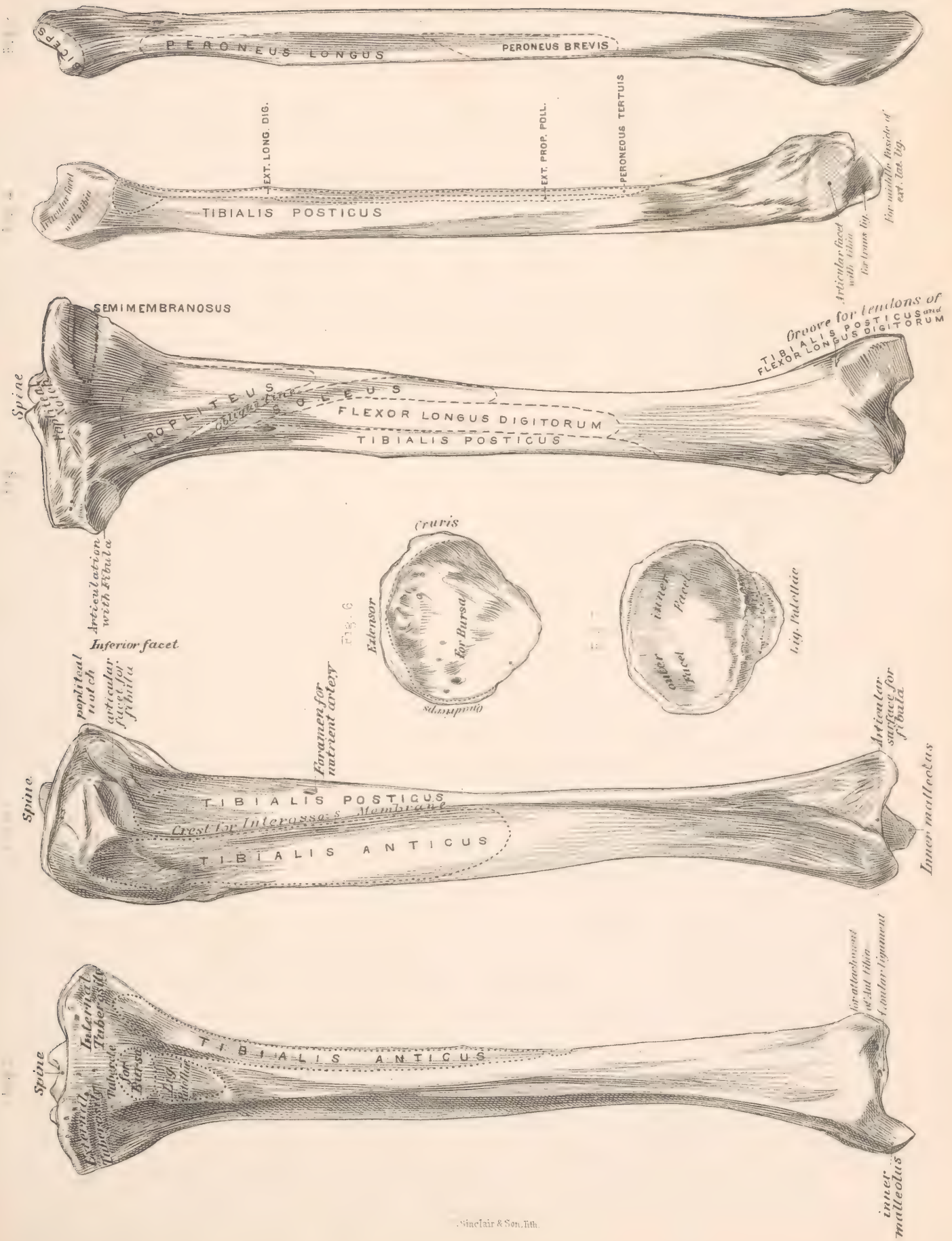
The Quadriceps muscle, by drawing the upper fragment away from the lower, creates a deep transverse sulcus. In place of a depression an elevation of the interosseous space may occur, an effect attributed by Jonathan Hutchinson[1] to the outward pres-

[1] N. Y. Med. Journ., iii., 1866, 41. [2] Ibid., 44.

[1] Med. Chir. Trans., lii. 340.

EXPLANATION OF PLATE XXXIV.

Fig. 1. The tibia, seen from in front.
Fig. 2. The tibia, seen from the lateral side.
Fig. 3. The tibia, seen from behind.
Fig. 4. The fibula, seen from the median side.
Fig. 5. The fibula, seen from the lateral side.
Flg. 6. The patella, seen from in front.
Fig. 7. The patella, seen from behind.



Sinclair & Son, lith.

sure of the synovial fluid of the joint. Union is almost always fibrous. Indeed, according to D. Hayes Agnew,[1] such a union is to be desired, since a true osseous union is liable to be destroyed.

The Bones of the Foot.

The bones of the foot (Plate XXXV.) are composed of the calcaneum, the astragalus, the cuboid bone, the scaphoid bone, and the three cuneiform bones, composing the *tarsus;* of the first, second, third, fourth, and fifth metatarsal bones, composing the *metatarsus;* and of the two toe-bones of the first toe and the three toe-bones in each of the remaining toes, that collectively constitute the *phalanges of the foot.*

THE TARSUS.

The Calcaneum.—The calcaneum (os calcis) is the largest bone of the tarsus, and constitutes the posterior abutment of the longitudinal arch of the foot. The shape of the bone is that of an elongated cube whose upper surface is irregularly depressed, and whose median surface is concave. The calcaneum articulates above with the astragalus, and in front with the cuboid bone. The bone is composed of a body and an anterior process. The *body* comprises the bulk of the bone, namely, the portion answering to the surface of articulation with the astragalus and the laterally compressed mass projecting backward from it to form the "heel." The *anterior process* is that portion of the calcaneum lying in front of the articulating surface for the astragalus, and it serves to articulate with the cuboid bone.—An imaginary line, passing round the heel directly behind the posterior margin of the ankle, indicates the so-called "neck" of the calcaneum.

In a more exact manner the calcaneum is described by its surfaces; these are six in number, as follows:—

The *superior surface* is divided into a posterior concave roughened surface which is free, and an anterior smooth surface for articulation with the astragalus. The last named is again divided into an anterior and a posterior portion, with an intervening depression. The anterior portion is elongated, concave, with sinuate margins; in front, as it overhangs the cuboidal face, a separate surface is often developed. The posterior portion is larger than the anterior, is sub-rounded, and looks downward and outward. It is supported by the stout process which has received the name of the *sustentaculum tali.* The depression between the two portions is narrow within, broad without, and yields attachment for the interosseous calcaneo-astragaloid ligament. When the calcaneum is in articulation with the astragalus, this depression is converted into a canal.—The *inferior surface* is narrowed from behind forward, and is marked at its posterior third by two tubercles named from their relative positions the median and the lateral *tubercle*, the former of which is much the larger. Probably the lateral tubercle sustains little or none of the weight of the body, since it is of merely muscular significance. It forms a round projection when seen from the lateral surface of the bone. Both tubercles afford points of attachment for the corresponding divisions of the plantar fascia, while the interval between them yields a surface of origin for the Flexor Brevis Digitorum. In front, on the median margin of the inferior surface, is a broad, slightly convex surface for attachment of the stout greater inferior calcaneo-cuboid ligament. The mechanical axis of the inferior surface of the calcaneum appears to lie obliquely to the *anterior tubercle*, for the attachment of the lesser inferior calcaneo-scaphoid ligament, inward and backward to the median tubercle, thus placing the lateral tubercle paraxially.—The *lateral* (external) *surface* is nearly vertical, and marked with numerous openings for bloodvessels. Placed near its middle is a welk-like rugosity, which, from the circumstance that it serves to separate the Peroneus Brevis from the Peroneus Longus muscle, is known as the *peroneal tubercle.* A second *tubercle* is situated near the cuboidal facet, and gives origin to the Abductor Minimi Digiti. In articulation it is a guide to the position of the calcaneo-cuboid joint.—The *median* (internal) *surface* (hollow of the calcaneum) is concave for the protection of the tendons of the posterior tibial muscles, and the plantar bloodvessels. The Flexor Longus Pollicis tendon lies in the best defined groove of the bone on the under surface of the *sustentaculum tali.*—The *anterior surface* is lozenge-shaped; the upper three-fourths of the space is occupied by an articular surface for the cuboid bone, and is triangular in form, the apex being directed upward. The facet is slightly convex laterally, but is concave medianly to form at the upper margin a conjunction with the astragalar articular surface. The lower angle of the anterior surface is roughened for the attachment of the inferior calcaneo-scaphoid ligament.—The *posterior surface* (calcaneal tuberosity, tuber calcis) is blunt and free. The upper portion inclines forward, and is covered with a bursa; the lower is roughened for the insertion of the tendo Achillis.

[1] System of Surgery, i. 980.

Structure.—The calcaneum presents a stout layer of compact tissue beneath the posterior astragalar articular surface and the depression in front of it; a second at the inferior surface by the bone directly beneath the foregoing; a third in the *sustentaculum tali;* and a fourth, much weaker, at the cuboidal surface. Elsewhere the interior is cancellous, and is composed for the most part of beautiful curved lines arranged in two sets, one extending from the cuboidal surface to the tuberosity, and concave upward; and the other ranging from the posterior astragalar surface to the tuberosity, and concave downward. A third set of radiating laminæ passes from the depression for the calcaneo-astragaloid ligament forward to the cuboidal surface. The laminæ at the upper half of the bone are coarser than those at the lower half.

Remarks.—In *talipes equinus* the calcaneum is slightly raised, and assumes an oblique position. The degree of the elevation is more apparent than real, and is, indeed, more marked in *equino-varus* than in true equinus. The bone may be in contact with the tibia behind. In *talipes varus* the calcaneum is drawn upward by the Gastrocnemius and Soleus muscles, and occupies a very oblique, almost vertical position, with a slight inclination inward. The calcaneum in the new-born child presents a smaller portion of the astragalar surface upon the outer aspect of the bone than in the adult.[1] The *sustentaculum tali* is enlarged in acquired *talipes valgus;* but is relatively small in *talipes varus.* Necrosis attacks the calcaneum with relative frequency. The centre of ossification has been lost by necrosis in a child aged three years, as in a case reported by Mr. Birkett.[2] Necrosis of the tibia of the corresponding side ensued.

Geo. Buchanan[3] reports a case of excision of the calcaneum.

The Astragalus.—The astragalus is, next to the calcaneum, the largest bone in the tarsus. It is placed between the bones of the leg above, the calcaneum beneath, and the scaphoid bone in front. It is irregularly cubical in shape, and, as usually stated, is composed of a body, a head, and a neck. The *body* answers in a general way to the surfaces of contact with the bones of the leg and the calcaneum, as well as to those occupied by the ligaments attached to the astragalus. The *head* is a synonym for the articular surface for contact with the scaphoid bone and the inferior calcaneo-scaphoid ligament. The *neck* is the constriction between the body and the head. It is better defined laterally (where it is narrow and depressed) than medianly (where it is broad, and makes up part of the median border of the foot) or inferiorly (where, indeed, its line bisects the calcaneal articular surface.)

In a more exact manner the astragalus is said to be made up of six surfaces: the superior, the inferior, the anterior, the posterior, and the two lateral surfaces.

The *superior surface* is for the most part occupied by the large facet for articulation with the axial distal surface of the tibia. It is narrower behind than in front; concave near the centre, but convex toward the two sides, the lateral side being the wider. In advance of the facet the superior surface includes the depressed proximal aspect of the neck.—The *inferior surface* is very irregular, and embraces three facets and a deep groove. The posterior facet for the corresponding posterior facet of the calcaneum is concave, broader behind than in front. It is obliquely placed to the axis of the bone, and, with reference to this axis, is disposed in the main to the lateral side. In front lies a deep groove for the attachment of the interosseous astragalo-calcaneal ligament. The remaining facets are contiguous in front of the groove, and include the oval surface for articulation with the anterior calcaneal facet, and a small ribbon-shaped facet (the head in part) for articulation with the inferior calcaneo-scaphoid ligament.—The *anterior surface* (the head in part) is an oblong, convex surface, whose longest diameter lies nearly at a right angle to the axis of the bone, but with an inclination downward and inward. It articulates with the scaphoid bone.—The *posterior surface* is a roughened, narrow ledge intervening between the tibial and the calcaneal articular surfaces. It is grooved toward the median side for the tendon of the Flexor Longus Pollicis. This groove is a valuable sign by which the surgeon can identify the astragalus in backward dislocation of this bone.—The *median surface* (inner) is irregular, and inclined a little inward. It is marked above, where it joins the superior surface at an angle, by a pear-shaped articular facet, for articulation with the internal malleolus. The base is directed forward, and lies in advance of the lateral articular facet. Below and behind this facet is the roughened surface for the attachment of the deltoid ligament. The median surface forms a well-defined limitation to the

[1] Huetter, Langenbeck's Archiv, iv., 1863, 475.
[2] Trans. Path. Soc. Lond., vi., 1856, 288.
[3] Edinburgh Med. Journ., 1876, 869.

neck anteriorly.—The *lateral surface* (outer) is in great part occupied by a facet. This is of a triangular shape, whose convex base is proximal, and whose apex is directed slightly outward. In advance of the lateral surface is a depression for the anterior lateral ligament; while behind lies a groove for the posterior lateral ligament. In front of the facet the surface is directed obliquely outward and forward, to form the lateral boundary of the neck. At a corresponding point beneath is the notch for the interosseous ligament. Behind, is the edge of the surface articulating with the body of the calcaneum.

To ascertain the side to which the astragalus belongs, place the bone with the superior facet upward; the side on which the neck is least defined will indicate the side to which the bone belongs; or, the position being the same, the external malleolar facet will point toward the side to which the bone belongs.

Structure.—The borders of the neck, both above and below, present a little compact tissue; elsewhere the bone is spongy. The lines of the laminæ are arranged in four sets. The first is composed of those finely textured cancelli underlying the proximal articular surface, and composing the bulk of the body of the bones; the second, of those passing from the posterior calcaneal surface, to join the first group; the third, of those stout, coarse lines extending directly backward from the scaphoid articular surface (the head) through the neck, to end abruptly against the first; and the fourth, of those weak lines passing obliquely upward and backward from that portion of the head in articulation with the inferior calcaneo-scaphoid ligament. The astragalus is weakest at the neck, where alone the third set of laminæ exists; it is here that the bone is most frequently fractured.

Remarks.—The changes in the foot after excision of the astragalus, together with the lower end of the fibula, in an instance recorded by Erichsen,[1] were as follows: The foot was drawn up by the tendon of the Tibialis Anticus muscle, and was slightly everted, forming a variety of *talipes equinus*. In another case of excision[2] the patient was able to walk three months afterward. The malleoli necessarily rest upon the calcaneum or the scaphoid bone. It is probable that in time a new joint may be formed between them and the bones of the leg; or anchylosis may ensue, as was found to be the case by E. Bellamy.[3] The power of adduction and abduction, of the foot in this condition, would be greatly impaired; as would also be the motions of the medio-tarsal joint.—Notwithstanding the preservation of all important muscular attachments, any sudden or violent attempt to throw the weight of the body upon the affected foot is liable to induce backward dislocation of the foot; the only force present resisting this tendency being the released fibulo-calcaneal and tibio-calcaneal ligaments.—After a careful study of three subsequent histories of removal of the astragalus for dislocation, J. Tufnell[1] concludes that a useful foot, such as would enable a laboring man to earn a livelihood, is not to be expected.

Mr. Wm. MacCormac[2] thus describes the position of the astragalus after a fracture and dislocation of the bone, of two years' standing: "The neck of the astragalus was fractured, the detached head remaining connected with the scaphoid; while the larger portion, or body of the bone, was completely displaced from between the malleoli backward and inward with a species of double rotation, so that the superior articulating surface was almost vertical, looked inward and slightly backward, and had the tendon of the Flexor Longus Pollicis fixed to it. . . . . The internal malleolus had been fractured, and between it and the inner border of the astragalus lay the tendons of the Tibialis Posticus and Flexor Longus Digitorum muscles."

The same author describes a second case thus: "The tibial surface was superficial, looking inward and slightly upward; the posterior extremity was directed downward toward the os calcis. Reduction could not be effected. The limb thirteen years afterward still exhibited the deformity as described. The man had very considerable movement in the ankle, and a slight degree of lameness was alone present."

In congenital *talipes varus* the shape of the astragalus is materially modified. The neck is longer than usual, and is more obliquely placed from without inward than in the normal bone. The head, in addition to its articulation with the scaphoid toward the inner border of the foot, is in part free beneath the skin of the dorsum of the foot. The superior articular surface at the ankle extends quite to the posterior edge of the bone, and is thin and wedge-shaped, instead of being obtusely rounded. The groove for the Flexor Longus Pollicis is absent.

In *talipes equinus* the astragalus inclines forward, in which direction it may be partially dislocated. In

[1] Med. Times and Gaz., Mar. 1860, 317.
[2] Med. Times and Gaz., Mar. 20, 1860.
[3] Trans. Path. Soc. Lond., 1873, 172.

[1] Dublin Medical Press, Dec. 28, 1853.
[2] Trans. Path. Soc. of Lond., 1875, 174.

talipes valgus, either congenital or acquired, the head of the bone can be easily defined under the skin, owing to the relaxed condition of the ligaments. The inner border of the head is very prominent.

Hueter has pointed out the fact that the neck of the astragalus in the infant is relatively longer than in the adult, and presents a nearly transverse scaphoid articular surface.

The astragalus is the only bone in the tarsus without muscular attachment.

The Cuboid Bone.—The cuboid bone is of an irregular cuboidal figure, broader behind than in front, and verging to the pyramidal form, since all its surfaces, excepting the median, slope toward the compressed lateral border. It is situated to the outer side of the foot, with the calcaneum behind, the fourth and fifth metatarsal bones in front, and the external cuneiform and scaphoid bone to the median side. It presents six surfaces for examination. The *superior* surface is smooth, and covered by the Flexor Brevis Digitorum. The *inferior* (plantar) *surface* is grooved obliquely for the tendon of the Peroneus Longus; behind the groove is a broad tubercle for the attachment of the greater inferior calcaneo-cuboid ligament. At the proximo-median angle is a rugosity for the attachment of the lesser inferior calcaneo-cuboid ligament. The *lateral surface* is grooved obliquely for the Peroneus Longus muscle prior to its entering the plantar groove. The *median surface* is flat, and marked with an oval facet for articulation with the external cuneiform bone, and commonly by a facet contiguous with the foregoing for the scaphoid bone. It is also roughened for the attachment of ligaments. The *distal surface* is subtriangular, and divided by a vertical ridge into two facets for the articulation of the fourth and the fifth metatarsal bones. The *proximal surface* is concave vertically, and convex from side to side to articulate with the calcaneum. Holding the bone with the grooved under surface downward, and the concave articular surface backward, the compressed border marked by the groove for the Peroneus Longus muscle will point to the side to which the bone belongs.

The Scaphoid Bone.—The scaphoid or navicular bone is placed on the inner side of the foot, having the astragalus behind it, the cuneiform bones in front, and the cuboid bone to the lateral side. It is compressed from behind forward, thicker below than above, and slightly inclined from beneath upward and outward. Above, the *proximal surface* is concave and pear-shaped, for articulation for the most part with the head of the astragalus. The *anterior surface* is curved transversely, and divided by two faintly marked, diverging ridges, defining three facets for articulation with the corresponding cuneiform bones. The *median surface* is broad, free, and somewhat roughened for the attachment of ligaments. The *lateral surface* is compressed, and commonly presents an uneven surface for articulation with the cuboid bone. The *inferior surface* is for the most part occupied by a pronounced *tuberosity* for the insertion in part of the Tibialis Posticus muscle. To the outer side of this prominence lies a narrow surface for the attachment of the inferior calcaneo-scaphoid ligament. According to Cruveilhier, the tuberosity may be greatly enlarged, and has been mistaken for an exostosis. It serves as a guide to the astragalo-scaphoid articulation. Holding the bone with the concave surface toward the observer, and the thickened end down, the narrow, roughened, lateral surface will point toward the side to which the bone belongs.

Remarks.—In pronounced *talipes varus* the tuberosity is in contact with the inner malleolus. The long axis of the bone is parallel with the long axis of the leg, instead of being at right angles to it. In *talipes equinus*, the scaphoid is drawn somewhat toward the plantar surface.

The Cuneiform Bones.—The three cuneiform bones are so named from the resemblance each bears to the figure of the wedge. They are lodged between

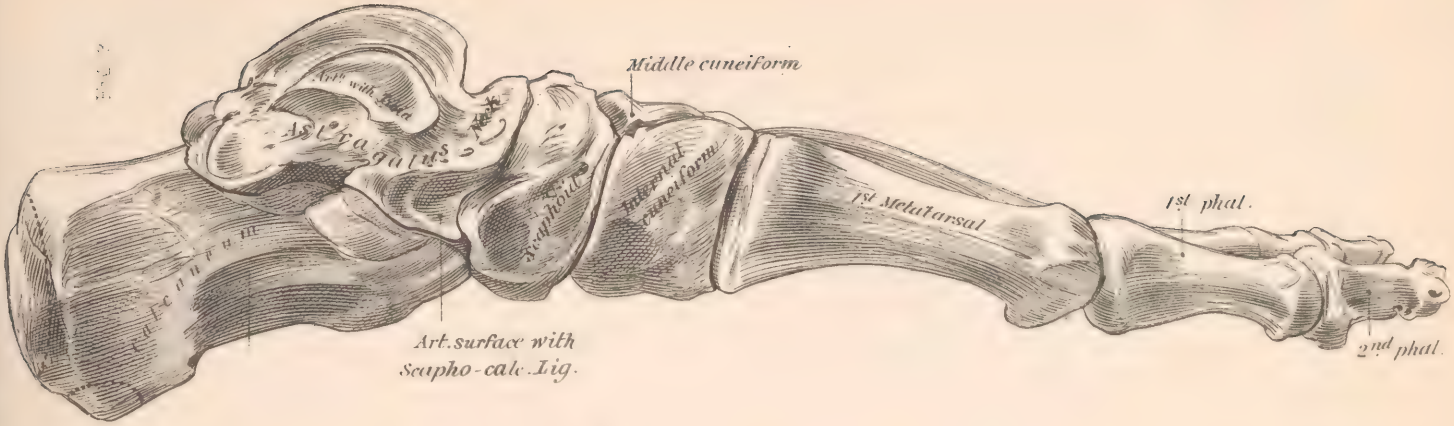
EXPLANATION OF PLATE XXXV.

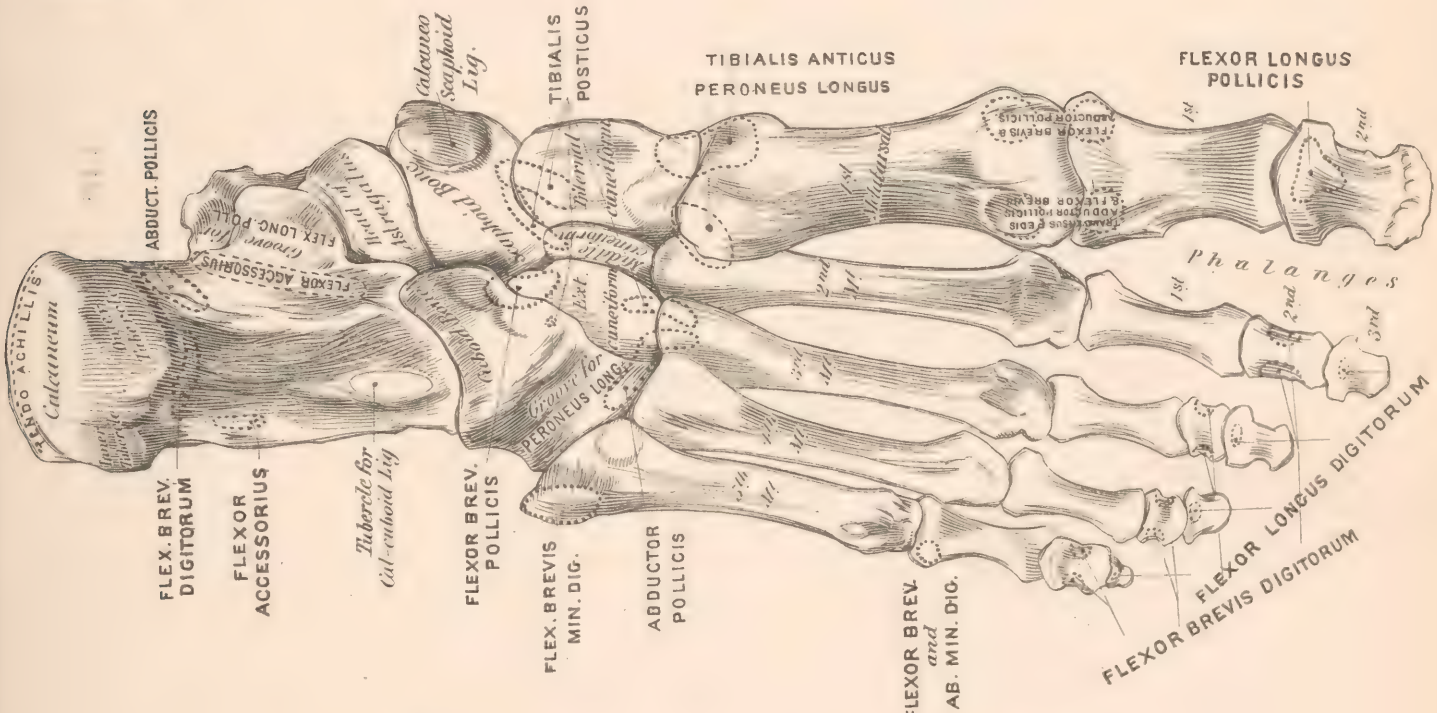
Fig. 1. The bones of the foot in articulation, seen from above.

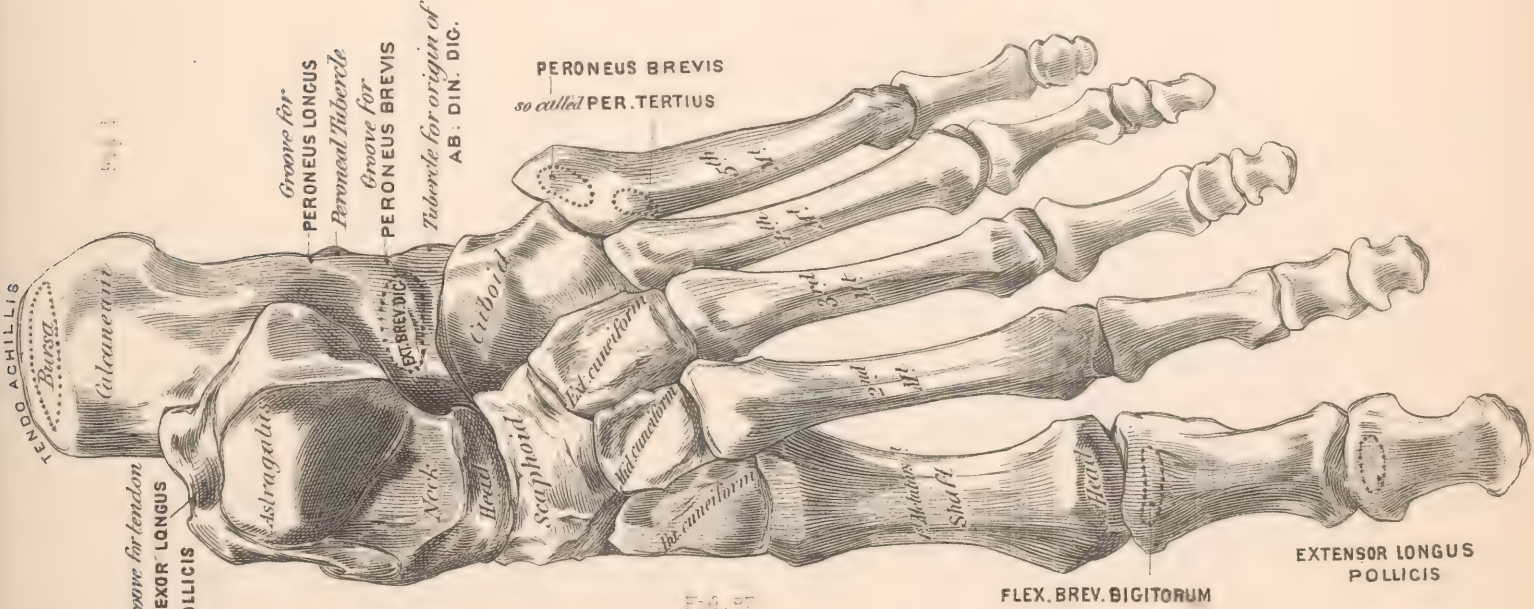
Fig. 2. The bones of the foot in articulation, seen from beneath.

Fig. 3. The bones of the foot in articulation, seen from the median side.

PLATE XXXV







T. Sinclair & Son. lith.

the scaphoid bone behind, and the first, second, and third metatarsal bones, respectively, in front.

With the *internal* (first) *cuneiform* the form of the wedge is obscured by having the convex base directed downward. The sides of the bone being curved, and the apex irregular, the bone projects distally nearly one-half its length beyond the second. The median surface is free, roughened, unequally convex, and marked below by a smooth surface for the tendon of the Tibialis Anticus muscle. The lateral surface is concave, and for the most part is markedly roughened for the attachment of ligaments, but faceted above for articulation with the middle cuneiform bone and the second metatarsal bone. Its proximal surface is pear-shaped, and presents a concave articular surface whose base is directed downward for articulation with the scaphoid bone. Distally a kidney-shaped facet is seen, its notch lying to the outer side, for articulation with the first metatarsal bone. The upper portion of the bone is angulated, and is thicker before than behind. The inferior portion is free, and projects conspicuously below the plane of the other cuneiforms to form the *tuberosity* which receives the tendon and attachment of the Tibialis Posticus and a portion of the Tibialis Anticus muscles. Holding the bone with its large end downward, the notch in the anterior facet will point to the side to which the bone belongs.

The *middle* (second) *cuneiform*, the smallest of the three, resembles a wedge to a greater degree than does either of the other cuneiforms. It is quadrangular on the dorsal surface, slightly narrow toward the distal end, and tapers at the plantar surface to a thin edge. The distal surface, designed for articulation with the second metatarsal bone, is broader below than the proximal which articulates with the scaphoid bone. The median surface is faceted at the upper half and along the proximal margin for the first cuneiform bone. The lateral surface articulates posteriorly and superiorly with the external cuneiform. Holding the bone with the broad end upward and the smaller end forward, the side with the smaller facet will point to the side to which the bone belongs.

The *external* (third) *cuneiform* recalls the general shape of the preceding, but is readily distinguished therefrom by its greater size, and by retaining the axis of the proximal articular surface at an angle to that of the distal. The bone projects about one-fourth its length distally beyond the middle cuneiform. The distal facet for the third metatarsal bone is longer than the proximal for the scaphoid bone, which in its turn is oblique from without inward, and from behind forward, and concave beneath where it yields a roughened surface for the attachment of ligaments. Laterally the third cuneiform presents at the junction of the dorsal and proximal margins a facet for articulation with the cuboid bone, and occupies about one-fourth of the lateral surface. Occasionally it presents a small facet at the dorsal edge of the distal border for articulation with the fourth metatarsal bone. Medianly the bone is depressed in the centre, and presents a roughened surface with two facets; the proximal of which articulates with the middle cuneiform, and the distal with the second metatarsal bone. Holding the bone with the base upward and the oblique facet backward, the lateral surface will point to the side to which the bone belongs.

REMARKS.—Dislocation of the second and third cuneiform bones on the dorsum of the scaphoid is described by Hancock.[1] The bones were excised, and the patient, a boy fourteen years of age, recovered. The bones of the tarsus are exceedingly liable to caries. Direct injuries except those arising from crushing degrees of force are infrequent. Small exostoses are not rarely seen on the dorsal surface of the first cuneiform.

THE METATARSUS.

The metatarsal bones are five in number, arranged in a transverse arch between the row formed by the cuboid and the cuneiform bones behind, and the phalanges in front. Each bone consists of a shaft and of a distal and a proximal extremity. The shaft is of a prismoidal form, and is more or less compressed laterally. The distal surface is convex, and the proximal flat or slightly concave.

The metatarsal bones are divided into those articulating with the first, the second, and the third cuneiform bones, and those articulating with the cuboid, namely, the fourth and the fifth. In each of the former group a line drawn along the dorsum, from the middle of the distal surface, will pass through the middle of the proximal surface. In the latter a line drawn from the same point as above will be directed to the outer margin of the bone before reaching the proximal surface.—The *first* bone of the series is the most massive. Its proximal surface is kidney-shaped with the notch directed outward, and is placed at right angles to the longitudinal axis of the bone. The distal surface, while convex and smooth above, is marked below by a median ridge defining two grooves, one on either side, for articula-

[1] Anat. and Surg. of the Human Foot, 1873, 95.

tion with the sesamoid bones.—The *second* is the longest of the series. It possesses a slightly concave triangular proximal facet whose apex is directed downward. It presents a roughened, flattened tubercle on the lateral side for ligamentous attachment with the third metatarsal bone. On the same surface the articular surface is divided into two facets by a sulcus. —The *third* possesses a proximal, flat, triangular surface. The lateral surface for ligaments is convex. The articular facet on this side is somewhat triangular; the dorsal border is nearly straight; the groove beneath the single facet is well defined.—The *fourth* metatarsal presents a proximal articular surface which is triangular; its apical portion is depressed, so that the surface has the appearance of having two facets. The external facet for articulation with the fifth metatarsal is triangular, with a convex dorsal border; the groove is very well defined.—The *fifth* metatarsal bone possesses a compressed shaft whose proximal surface is flat or oblique. The median surface is large, with a small ridge on the proximal border, which is received within a groove upon the lateral surface of the fourth metatarsal. The lateral border is prolonged into a process proximally near the plantar surface, but separated from the articular surface by a groove.

Synoptical Table of the Metatarsal Bones.

The axis of the dorsal aspect of the distal surface cuts the proximal surface of the first, the second, and the third metatarsal bones, as they articulate with the cuneiforms.

- Without lateral facets, and possessing grooves for the sesamoid bones on the distal surface. The proximal surface is reniform, with its dorsal border arranged transversely to the longitudinal axis . . . . . First.
- With facets on either side of the proximal extremity . . . . . Second, third, fourth.
  - The external lateral surface with faintly marked groove, and flattish tuberosity; proximal surface triangular, concave . . . . . Second.
  - The external lateral surface with facet concave, dorsal border straight; the groove is narrow, defined; the tuberosity pronounced; proximal surface triangular and flattened . . . . . Third.

The axis of the dorsal aspect of the distal surface does not cut the proximal surface of the fourth and the fifth metatarsal bones as they articulate with the cuboid.

- The lateral surface flat with convex dorsal borders; the groove deep, the tuberosity pronounced. The proximal surface triangular with apical third depressed . . . . . Fourth.
- The facet on proximal end on one side only (median), external tubercle large . . . . . Fifth.

THE PHALANGES.

These agree with the characteristics of the corresponding bones of the hand to such a degree that little need be said in detail in this connection.

The most marked peculiarities are the following:—The phalanges of the first toe are relatively larger than the same bones of the hand, while those of the remaining toes are relatively smaller. The shafts of the bones, excluding those found in the great toe, are more compressed laterally. The phalanges of the fourth and fifth middle toes, as well as the first phalanx of the great toe, are apt to be deformed in the skeletons, as seen in our cabinets, by reason of the almost universal practice of wearing ill-fitting shoes.

The *sesamoid bones* are placed on each side of the plantar surface of the distal end of the first metatarsal bone. They are osseous developments within the tendons of the Flexor Brevis Pollicis. They are faceted on their dorsal, but are free and roughened on their plantar surfaces. They can be felt obscurely beneath the skin in the undissected subject.

THE FOOT.

When the bones of the foot are in articulation with each other an elongated figure results, which is narrow and compact behind; broad and spreading in front; convex above, but concave, irregular, or flat below.

The bones of the tarsus are arranged in rows, with the exception of the astragalus which overlies the calcaneum. The distal surfaces of both the last-named bones advance to nearly the same level, and form the proximal surfaces of the *medio-tarsal joint*, to which the scaphoid and the cuboid bones contribute the distal surfaces. The tarsal (in advance of the medio-tarsal line) and the metatarsal bones are more or less arched transversely (frontally). The *tarso-metatarsal joint* is curved forward, and the median end is advanced beyond the lateral. The proximal end of the second metatarsal bone is sunk in a depression called the *mortise*, between the first and the second metatarsal bones. The phalanges are arranged in a nearly flat series, and present proximal

surfaces on a single line, save the fifth alone, which is advanced proximally beyond that of the others.

Among the remaining parts defined by the union of the bones, but absent or not well seen in the isolated bones, may be mentioned the following:—

The canal that is formed between the astragalus and the calcaneum.

The oblique groove extending across the plantar surface from the lateral border of the cuboid bone, forward and inward; this is the *peroneal* (plantar) *groove* for the accommodation of the tendon of the Peroneus Longus muscle.

An eminence at the dorsal surfaces of the first and second cuneiform bones that has received the name of the *instep*.

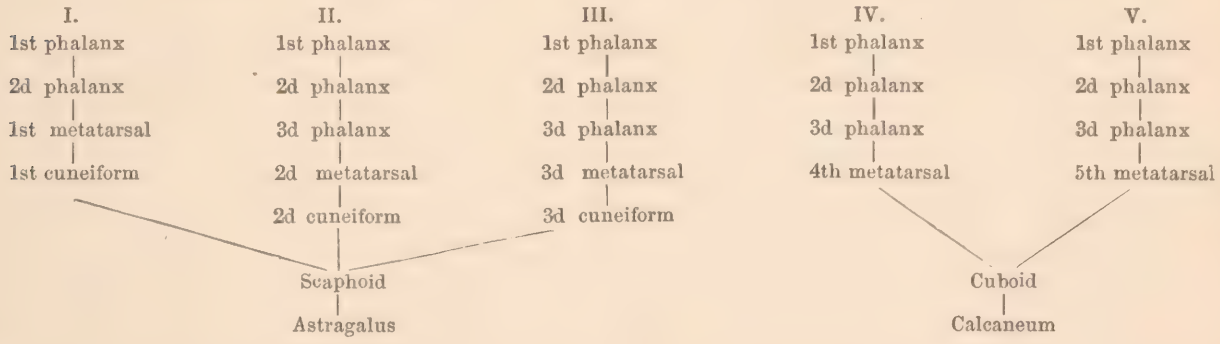
The portion of the calcaneum projecting posteriorly to the astragalus and forming the "heel." Duchenne[1] describes the heel as the "arrière pied," as opposed to the foot in advance of the ankle, which he calls the "avant pied."

Interosseous spaces are formed between the metatarsal bones and the phalanges. Of these the space between the bones of the first and the second of the series is the widest.

The median border of the plantar surface is robust distally, and ends abruptly with the scaphoid proximally. The lateral border of the same surface is weak distally, but becomes increasingly robust proximally, to end in the enormous median plantar tubercle of the calcaneum.

The bones of the foot are arranged in two longitudinally disposed series—a median and a lateral. The *median* series is composed of the phalanges of the first, the second, and the third toes, and of the metatarsal and tarsal elements with which these articulate. The *lateral* series is composed of the fourth and fifth toes and of their respective metatarsal and tarsal bones. Seen in a tabular form the arrangement is easily followed.

A Table of the Bones of the Foot arranged in Longitudinal Series.



When the weight of the body rests upon the *flexed* lower extremity, and the heel is elevated, the tibia is inclined forward upon the widest portion of the superior articular surface of the astragalus; the greater part of the weight is thus transmitted through the last named bone to the *median series* of the foot as far as the metatarso-phalangeal joints, beneath which in the living subject is the callous pad, the ball of the toes. Along this line the articular surfaces of the bones are composed of proximal convexities resting within distal concavities—in a word, of a series of segments of balls resting within partial sockets. The weight is in part sustained by the plantar ligaments.—The *lateral series* in this position has but slight work to do, viz., to act as a crutch to the *median*.—When the weight of the body is borne by the *extended* lower extremity, the foot rests firmly on the ground, and the weight is in part transmitted from the astragalus to the calcaneum, and thence to the cuboid bone and the bones of the fourth and the fifth toes. The median series receives, however, much of the weight of the body by means of the head of the astragalus resting in this position in the concavity of the scaphoid bone, and on the inferior calcaneo-scaphoid ligament. The impress of the foot is greater on the lateral than on the median side.[1] According to F. O. Ward,[2] the attitude first described is employed to distribute the force of sudden concussion, as from a jump; the second posture is assumed when the foot is required to sustain some heavy continuous pressure, that of the trunk for instance, augmented, as it often is, by the addition of a ponderous burden.

[1] Physiologie des Mouvements.

[1] Boston Medical and Surgical Journal, xc. 48.

[2] Outlines of Osteology, 367.

The tarsal and the proximal ends of the metatarsal bones of the median series, excepting the astragalus, tend to form wedges (least pronounced in the scaphoid) whose bases are either dorsal or plantar; while those of the median series are wedges whose bases are lateral (least pronounced in the fourth metatarsal). The plantar surface of the median series is acutely arched at the tarsus and the metatarsus, while the plantar surface of the lateral series is flat. It is of interest to note that wounds of the lateral series are less severe than those of the median.

In addition to the disposition of the bones above noted, the foot, when studied as a separate mechanism, yields two principal arches—the longitudinal and transverse—which are arranged to sustain the weight of the body, and to protect the plantar nerves and bloodvessels. The *longitudinal arch* is not an exact figure, since it is composed of the oblique line extending from the ball of the foot to the summit of the astragalus, and thence, by an abrupt descent, to the external plantar tubercle of the calcaneum. The *transverse arch* is best defined at the medio-tarsal joint, between the plantar surface of the first cuneiform bone and the lateral border of the cuboid. Both the longitudinal and the transverse arches are subject to modification. The formation of the transverse arch depends upon the ability of the bones composing it to be accurately adjusted by pressure; upon the degree and the kind of motion permitted between the bones; upon the nature of the connecting ligaments, as well as the lines of traction of powerful muscles. When the arch is relieved from the strain of the weight of the body, it assumes a narrow and high position; but when it sustains the weight of the body, it tends to become flattened, and would be obliterated were it not for the weight forcing the lateral and the median ends of the arch to the sides, at the same time that the dorsal approximal angles of the bones are tilted toward each other. As the arch is thus retained, the ligaments and the tendons of muscles passing between the plantar surfaces and the corresponding surfaces of the other bones become tense and limit the degree of motion.

The muscles that sustain the arch are the Tibialis Anticus, the Tibialis Posticus, and the Peroneus Longus. When, apart from the condition of the bone, softening of the ligaments or paralysis of the muscles ensues, the efficacy of the arch is impaired, and may be destroyed. Flat foot and various pseudo-neuralgic conditions may result from such failure of action.

Development.—The tarsal bones ossify after the following method: Each arises from a separate centre, except the calcaneum, which retains an epiphyseal centre at the surface of attachment of the tendo Achillis. The calcaneum receives its bony nucleus at the sixth month; the astragalus at the seventh month; the cuboid at the ninth month; the third cuneiform at the first year; the internal cuneiform at the third year; and the scaphoid and middle cuneiform at the fourth year. The calcaneal epiphysis joins the body of the bone at the tenth year. Gruber[1] reports a case in which the portion of the astragalus accommodating the tendon of the Flexor Longus Pollicis existed as a distinct ossicle.

The metatarsal bones and the phalanges develop after the method of the similar parts in the hand. Each bone presents a single nucleus for the shaft or body, and one for an epiphysis. The epiphyseal nucleus is distal in the metatarsal bones from the second to the fifth, but is proximal in the first. The epiphyseal nucleus is proximal in all the phalanges. The order of ossification is as follows: In the metatarsal bones the nuclei of the shafts appear in the eighth or ninth week. The epiphyses appear from the third to the eighth year, and unite with the shafts from the eighteenth to the twentieth year. The nuclei of the shafts of the phalanges appear in the ninth or tenth week. The epiphyses appear from the eighth to the tenth year, and unite with the shafts from the nineteenth to the twenty-first year.[2]

[1] Archiv. Anat., Physiol., und Wissensch. Medecin., 1864, 286.
[2] Quain's Anatomy.

THE JOINTS AND THE LIGAMENTS.

GENERAL CONSIDERATIONS.

Joints or articulations are those portions of the body which serve to hold the bones in their natural relations to one another. They assist the bones in supporting the soft parts of the body, and in resisting shock. They thus resemble the skeleton, with which division of anatomy some writers include them. In their simplest forms they are composed of capsules, ligaments, synovial membranes, fibro-cartilage, and the cartilaginous coverings of the ends of the bones. It follows that a description of a joint must be in part a repetition of the account of such surfaces of the bones as are apposed within the joints.

Ligaments are bundles of fibrous tissue that assist the joint surfaces in maintaining contact, and in limiting their ranges of motion. In all their functions they act in conjunction with muscles. They are flexible structures, and are attached to the bones they unite; they are often continuous with the periosteum, and are intimately incorporated with the origin and the insertion of muscles.

In the study of the joints it is assumed, as above mentioned, that the cartilaginous surfaces are retained upon the ends of the bones, and that they, together with the accessory parts, are inspected in the living condition.

The following are the definitions of terms used in the descriptions:—

A Ligament is that structure which unites two separate bones. It may be composed of fibrous or elastic tissue. Prominent folds of synovial membrane are for convenience also termed ligaments.

Ligaments exist either in the form of capsules or of separate bands or thongs.

A Capsular Ligament is a bag of fibrous tissue holding the apposed ends of bones together. It forms the foundation of the movable joint. It is uneven and fasciculated on the outside, but smooth on the inside, where it is covered with the synovial membrane.

Accessory Ligaments are those which aid in supporting the capsular ligament. The internal lateral ligament of the temporo-maxillary articulation is such a structure. Accessory ligaments may pass over large portions of a single bone, or over many bones.

Check Ligaments are those which limit the action of articular surfaces. The term is restricted by the older writers to a special ligament which limits the motion of the median atlo-axoid articulation. But in a more exact sense most of the ligaments about the joints of the limbs check undue motion of the articular surfaces. Thus the lateral ligaments of the joints between the phalanges check the lateral motion; the inferior calcaneo-scaphoid ligament checks the otherwise too free motion of the astragalus, etc. It follows that rupture of a check ligament will create dislocation.

A Facet is a portion of articular surface which is distinguished from adjacent portions of the same surface by difference of curvature. Thus the occipital condyle has two facets, the patella seven, the head of the astragalus four, etc.

Fibro-Cartilage is a tissue which has, as the name indicates, the properties of both fibrous tissue and cartilage. There are three varieties of fibro-cartilage —interosseous, interarticular, and circumferential.

Interosseous fibro-cartilage is found between the bodies of the vertebræ, or between the pubic bones. It is firmer at the periphery than elsewhere, and may con-

tain in the centre, as in the last-named example, a synovial sac.

Interarticular fibro-cartilage (meniscus) is found between articular surfaces, and divides the joint more or less perfectly into two compartments. The plate may extend entirely across the joint, as at the sterno-clavicular and temporo-maxillary articulations, in which forms it is apt to be thinned toward the centre; or it may be crescent-shaped, and fixed laterally to the capsule or ligaments of the joint, the remaining portion lying free in the joint, and covered with synovia on both sides.

Circumferential fibro-cartilage is the name given to bands at the edges of sockets of bone, which serve to deepen the sockets. Such, for example, are the cotyloid ligament of the hip bone, and the glenoid ligament of the shoulder-blade.

Synovia is the fluid secreted by a synovial membrane. It is a transparent, alkaline, albuminate fluid, of glairy consistence, yellowish color, and saltish taste. A *synovial membrane* is a delicate structure allied to serous membrane, and lines the joint cavity. It sends occasional pockets or culs-de-sac among the accessory ligaments or adjacent muscles.

ON THE ACTION OF JOINTS.

A correct conception of the following subjects is demanded in studying joint-action: Atmospheric pressure, action of ligaments, presence of synovia, action of muscles, and the shapes of facets.

Atmospheric Pressure.—The pressure of the atmosphere upon a joint forces the cartilages against one another, and the more yielding soft parts inward from all sides. The tags of synovial membrane occupied by fat are by the same pressure driven into spaces in the joint unoccupied by cartilages or capsule. When a joint is filled with fluid, as for example serum or pus, or, as in the course of experimentation on the subject, with water or air, the contact between the bones is broken. Atmospheric pressure, therefore, as exerted upon a healthy joint, precludes the existence of a joint cavity in the proper sense of the term.

Atmospheric pressure is best studied in joints having wide range of motion. In the knee, for example, when the condyles of the tibia are resting upon the posterior portions of the condyles of the femur (that is to say, the joint being in the position of extreme flexion), the anterior parts of the joint are separated from one another, and the integument on either side of the patellar ligament is to be seen depressed: the weight of the atmosphere, it is thought, has pushed the superficial parts in to occupy the otherwise gaping interval in the front of the joint. The brothers Weber found that the hip-joint remained intact as long as the normal relations to the atmospheric pressure were maintained. But the moment an opening was made through the bottom of the acetabulum the femoral and acetabular surfaces spontaneously separated.

Action of Ligaments.—The ligaments assist in maintaining contact between joint surfaces, and in limiting the motion of articular surfaces.

Presence of Synovia.—Synovia lubricates the interior of the joint, and lessens friction.

Action of Muscles.—No theory of joint action is complete without a knowledge of the action of those muscles that either cross over joints, or have their attachments at or about them. Appropriate muscular action determines the normal lines of pressure and resistance, and indicates the direction of motion of the various parts of the joint in changing from a flexed to an extended position. In joints of simple construction muscles may take the place of accessory ligaments, as, for example, in the shoulder, where it is shown that paralysis of such muscles causes the head of the humerus to fall away from the glenoid cavity of the scapula. It is probable that muscular action may serve as a compensating force in maintaining contact between the articular surfaces when the ligaments are softened and relaxed by diseased action.

The Shapes of Facets.—As the distance of the articular surfaces from one another in the healthy joint is invariable, and the condition above named nominally present, the degree of muscular power required to cause the curve-like motions of the joints is not so great as would at first sight be supposed. The shapes of the joint surfaces assist the ligamentous or other checks in preventing too great latitude of motion. It is evident that the articular surface of the coronoid process of the ulna, for example, limits the degree of flexion of that bone upon the humerus, as the surface of the olecranon limits its extension. In like manner the entire ulno-humeral joint acts as a check to the radio-humeral rotatory motion, if indeed it does not convert it in the acts of flexion and extension from a rotatory to a ginglymoid joint. The slightly oblique path of movement of the humero-ulnar joint is checked by the direct path of movement of the radius on the humerus. In carnivorous animals, such as the badger, the motions of the temporo-maxillary joint are strictly confined by con-

spicuous processes, descending both in front and behind the temporal cavity to embrace the neck of the lower jaw so that the otherwise shallow socket is deepened. May not the significance of all forms of deep sockets depend upon the development of these retaining check processes? and may not the greater limitation of motion in the hip compared with that of the shoulder be due to the circumferential check surfaces of the former?

SUTURA.[1] Sutures are the common mode by which the bones of the cranium unite, and they are not seen in any other part of the adult skeleton. They are generally described as being of four kinds, as follows: *The harmonic suture.* This is defined where two nearly smooth surfaces are opposed. The irregularity of many parts of the harmonic suture gives the clue to the significance of the remaining three. Examples are seen between the two horizontal plates of the superior maxillæ, and between the corresponding plates of the palatal bones.—*The squamosal suture.* This variety is characterized by two bevelled surfaces which are opposed the one to the other. The outer overlaps the inner, and suggests an arrangement similar to that existing between the scales of fishes. An example of the squamosal suture is seen in the human body in the union between the squamous portion of the temporal bone and the parietal bone.—*The dentate suture.* In this form tooth-like processes project from the opposed surfaces.—*The serrate suture.* This resembles the dentate, but is distinguished by the processes being more or less saw-like. The so-called *limbose suture* is a combination of the squamosal and serrate.—The interparietal suture is an instance of the dentate and the interfrontal of the serrate.—The sutures seen on the under surface of the calvarium are all harmonic, no matter what they may be upon the upper surface.

Following upon external force an imperfectly defined motion is permitted between bones united by sutures that have not attained their full degree of development. The most important of these, according to P. Budin,[2] takes place in the fœtal skull at the suture between the ascending portion of the occipital bone and the centres at the sides of the foramen magnum. The motion of the former upon the latter is described by this writer as hinge-like in character. When the ascending portion is bent forward on the suture, it is said to be flexed, and when backward, to be extended. Budin believes that one or the other of these movements, according to the presentation of the head, always takes place during parturition.

SYNCHONDROSIS. Synchondrosis serves to unite the several centres in immature cartilage-bones. In the long bones it joins the epiphyses with the shaft, and the different centres of the irregular and tabular bones with one another. Good examples of synchondrosis are seen between the sphenoid and the occipital bones, at the costo-sternal articulation, in the body of the sternum, and among the different parts of the hyoid bone. The motion of synchondrosis is exceedingly slight.

SYMPHYSIS. The bone-surfaces in symphysis are flat and gently concave, as in the vertebræ, or irregularly sinuate, as in the pubic bones at the interpubic articulation. The surfaces are not free, but are held together by disks of fibro-cartilage, the short, tense fibres of which are so arranged that they are compactly interlaced toward the periphery, but are elastic and succulent toward the centre. In the interpubic articulation a synovial sac may be present. The bones uniting in a symphysis are further strengthened by accessory bands.

Symphysis, as here defined, includes the amphiarthrosis[1] of the older writers. Meyer includes symphysis under arthrodia,[2] intending thereby to bring together all forms of broad and nearly flat movable articular surfaces.

Examples of symphysis are seen between the bodies of the vertebræ (excluding the atlas and the axis), between the sacrum and the coccyx, between the pubic bones, and between the ilium and the sacrum.

Both synchondrosis and symphysis require considerable exercise of force to disturb their equilibrium, and when the force ceases to act the joint surfaces resume the position of rest by reason of their own elasticity. Hence no forms of check or limiting mechanisms are met with in these joints.

[1] For the classification of joints see the table on p. 208.

[2] De la Tête du Fœtus au Point de Vue de l'Obstétrique. Paris, 1876, 72.

[1] Amphiarthrosis also embraced the union between the different carpal and tarsal bones, especially where flat surfaces were connected by interosseous ligaments.

[2] The term "Arthrodia" is already in use to signify a group of articulations having a subordinate position in the one this writer would assign it. If it be held to be important to have a word to include all forms of movable joints, the word Lyenarthrosis is suggested as one that would be appropriate. This word implies that a joint therein placed is *unfixed*, as opposed to any given variety of Sutura and Synchondrosis which is *fixed*.

Table of Joints.[1]

SUTURA, includes the union of bones arising from membrane. The bone surfaces are varied.

- Harmonia, when the surfaces are smooth or slightly irregular.
- Squamosa, when they overlap like the scales of a fish.
- Dentata, when the edge of the bone is armed with tooth-like processes.
- Serrata, when the processes named in the last group are saw-like.

SYNCHONDROSIS, includes the union with cartilage of bones arising from that tissue. The bone surfaces are flat or irregular.

SYMPHYSIS, includes the union by means of fixed fibro-cartilage of bones which are without encrusting cartilages. The articular surfaces of the bones are flat or nearly so.

DIARTHROSIS, includes the union of bones that present to one another convex or concave surfaces of encrusting cartilages, and are covered with synovial membrane.

- Diarthrotic joints are called Arthrodial when the curvatures are faintly expressed.
- They are called Spherical when the curvatures are pronounced and their radii equal.
- They are called Cylindrical when the curvatures are pronounced and their radii unequal.
  - *Hinge*, with a trochlear or pulley-like surface.
  - *Screw*, with axis oblique to axis of bone.
  - *Saddle*, with opposed surfaces resembling those of a saddle.
- Conical, when the form is that of a cone.
- Composite, when the various features of diarthrosis are combined.

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[1] The classification used by English writers (see Gray's Anatomy) is herewith presented for purposes of convenience in reference.

- *Synarthrosis* or immovable joint. Surfaces separated by fibrous membrane, without any intervening synovial cavity, and immovably connected with each other. As in joints of cranium and face (except lower jaw).
  - *Sutura.* Articulation by processes and indentations interlocked together.
    - *Sutura vera* (true) articulate by indented borders.
      - *Dentata*, having tooth-like processes. As in interparietal suture.
      - *Serrata*, having serrated edges, like the teeth of a saw. As in interfrontal suture.
      - *Limbosa*, having bevelled margins, and dentated processes. As in fronto-parietal suture.
    - *Sutura notha* (false) articulate by rough surfaces.
      - *Squamosa*, formed by thin bevelled margins, overlapping each other. As in squamo-parietal suture.
      - *Harmonia*, formed by the opposition of contiguous rough surfaces. As in intermaxillary suture.
  - *Schindylesis.* Articulation formed by the reception of a thin plate of one bone into a fissure of another. As in articulation of rostrum of sphenoid with vomer.
  - *Gomphosis.* Articulation formed by the insertion of a conical process into a socket. The teeth.
- *Amphiarthrosis.* Mixed Articulation.
  1. Surfaces connected by fibro-cartilage, not separated by synovial membrane, and having limited motion. As in joints between bodies of vertebræ.
  2. Surfaces covered by fibro-cartilage; lined by a partial synovial membrane. As in sacro-iliac and pubic symphyses.
- *Diarthrosis.* Movable joint.
  - *Arthrodia.* Gliding joint; articulations by plane surfaces, which glide upon each other. As in sterno- and acromio-clavicular articulations.
  - *Enarthrosis.* Ball-and-socket joint; capable of motion in all directions. Articulations by a globular head received into a cup-like cavity. As in hip and shoulder-joints.
  - *Ginglymus.* Hinge joint; motion limited to two directions, forwards and backwards. Articular surfaces fitted together so as to permit of movement in one plane. As in the elbow, ankle, and knee.
  - *Diarthrosis rotatoria* or *Lateral Ginglymus.* Articulation by a pivot process turning within a ring, or ring around a pivot. As in superior radio-ulnar articulation, and atlo-axoid joint.

The above classification is based upon a mixture of form and function, and is arbitrary. The one proposed in the text is based upon form alone, and is in harmony with the facts of development.

The main divisions of the old classification suggest three varieties of joint—the immovable, the mixed, and the movable. But joints either move or they do not; the language designed to describe an intermediate, mixed joint is of necessity inexact.

The varieties Schindylesis and Gomphosis are ignored in the classification of the text. The former is not a suture, since it occurs beween two bones of cartilaginous origin. It is a coaptation, the result of an obliterated synchondrosis, a condition which does not demand a special name. The term "fissure" is inappropriate for the sphenoidal aspect of the vomer. Of variable form, this surface is often narrowed, but never fissured.—The insertion of the teeth in sockets is in no sense articular. "Gomphosis" should be omitted from a classification of joints.

The term Symphysis is employed in place of "Amphiarthrosis," which, as a term having systematic value, is discarded. The presence of a synovial sac in some forms of symphysis is not sufficient ground on which to base a distinct variety.

Diarthrosis and its divisions are essentially the same as in the classification adopted in the text.

Symphysis permits of a slight motion only between the bones united by its means. When a number of small bones, as the vertebræ, are thus joined, the motion between any two is inconsiderable, but is naturally greater when the joints between all the bones act together. The motions of the vertebral column are by this means shown to be great; for the backbone can be flexed, extended, and bent from side to side. At the pubis the union enables a slight outward stretching to occur in child-birth. The surfaces here may also glide slightly upon one another, especially if the synovial sac is developed.

Diarthrosis. In diarthrosis the opposed bony surfaces are concavo-convex. The bones are free; the synovial membrane constant; the capsule loose, and ordinarily strengthened by muscles and accessory ligaments. The joints of the limbs are exclusively of this character. They range from the simplest to the most complicated forms. So great is the motion permitted in diarthrosis, that all the surfaces of a given joint are never in contact with one another at the same time. In each particular position assumed, in passing from complete flexion to complete extension, opposite facets, that are specially adapted to maintain such position, are brought in contact with each other. Such areas of contact change successively as the path of movement (by which term is meant the direction taken by a given articular surface in gliding over another) is followed. In the knee-joint, for example, it is found that in flexion the tibio-femoral facets near the posterior aspect of the joint are in contact, while the anterior surfaces are separated. In like manner, during extension the anterior surfaces are in contact, while the posterior are separated. The parts in contact may be said to be active, and those not in contact to be at rest. In addition to the above it may be seen that one of the bones composing the joint is fixed or inclines to be, while the other moves upon it. The fixed portion furnishes the *axis of rotation*. The plane on which the moving bone swings is the *plane of motion*, and moves in certain relations to the *axis of rotation* according to the special shapes of the joint surfaces. Thus in a rotary joint the plane of motion is called the *plane of rotation*, and in a hinge joint the *plane of flexion* or *extension*.—A pair of corresponding facets which are known to be active in certain positions of the joint may be called after the kinds of activity they are engaged in. Thus one can speak of facets of flexion, or the facets of extension, etc.

When the convexity is proximal, and the concavity distal, as in the astragalo-scaphoidal joint, the idea of the convexity *resting* within or upon the concavity is suggested; whereas, when the concavity is proximal, and the convexity is distal, as in the shoulder-joint, the idea of the convexity falling away, or *swinging* within the concavity, is suggested. The former of these joints expresses a state of rest; the latter one of motion.

The proper method of studying the motions of diarthrodial articulations is as follows:—

(1) The simplest form of an articulation is that in which the distal facet of one bone is in the same axis as the proximal facet of the opposed bone. Such joints may be termed *primary joints*, and the two corresponding facets, *primary facets*. In the knee-joint it is found that the longitudinal axis answers to the outer femoral condyle, and hence the *primary* facet is to be found upon this surface; while the facet formed upon the inner femoral condyle is not primary, but *secondary*, and is a special feature added to the primary character of the joint.—The articular surfaces upon the sides of certain bones, as those between the tarsal and the metatarsal bones, and between the tibia and the fibula, are of significance different from that of either of the preceding; these may be termed the *lateral* or *tertiary* facets.

A joint may be said to be at rest when the least amount of pressure exists between its opposed facets. It has been already noted above that extremes of extension and flexion fix a joint. The position of rest is ordinarily one between these two extremes, namely, the one termed *semi-flexion*.

The supine position tends to rest the joints of the limbs, particularly those of the lower limb, since it removes the pressure of the weight of the body. If, however, the assumption that muscular action controls joint movements be correct, it follows that joints cannot be rested even in the supine position so long as their muscles are acting inordinately or in vicious directions. Hence the question of the rest of muscles enters into every problem of rest, and lies at the basis of all rational treatment of joint diseases. Any apparatus designed to keep the joint at rest must include all the muscles acting upon it.

(2) The presence of a disk of fibro-cartilage between two cartilaginous articular surfaces tends to divide the joint, in a mechanical sense, into two chambers; in the knee there is a chamber between the femur and the disk on the one hand, and the disk and the tibia on the other.

When it is remembered that these disks are,

primarily, outgrowths from the capsule in the motions of which they participate, and into which, as in the external inter-articular disk of the knee-joint, they project, it is seen that these disks are important factors in the movements of the articulations. When the living subject is standing erect, and the weight of the body is thrown chiefly upon the outer femoral condyle, the action of flexion is initiated by the change in position of the external disk, by means of which the tibia is moved slightly inward, and placed in a favorable position for gliding backward or inward along the inner femoral condyle.

Flexion indicates the position of the limb in which the most acute angle possible exists between its segments.[1] *Extension* is the reverse of flexion; it is the position in which the angulation between the segments is the least possible. If extension is carried beyond 180°, dorsal flexion begins. In flexion and extension, viewed as one movement, a form of rotation is seen, the distal end of the movable bone describing a wide arc of a circle about that of the fixed bone.

Rotation is a movement of a bone upon itself in its longitudinal axis, as in the motion of the radius on the ulna. When rotation occurs with the limb describing a circle it is called *circumduction*, and is the direct transmutation of one position of flexion into another, and the rotation of one or both bones in any position which the two bones may effect toward each other.

Adduction is the traction of the part toward the median line. *Abduction* is the traction of the part away from the median line.

When a movable articulation becomes immovable it is said to be *fixed*, and the passage from one to the other condition is controlled by muscular action.

THE ARTHRODIAL VARIETY OF DIARTHROSIS; OR THE FLAT JOINTS.—In this, the simplest form of diarthrosis, the surfaces are so slightly concavo-convex that they have been described by some writers as plane.

In the assertion often made that the apposed surfaces of some bones are almost flat, we have no proper distinction drawn between the infinitely large varieties which can be created by slightly modifying nearly flat surfaces. It would be more accurate to say that such bones are opposed to one another by slightly concave and slightly convex surfaces, and that the motions between such surfaces do not glide so much as they rotate one upon the other, and are thus seen not to differ in kind from any other form of diarthrosis. In a joint of this kind the movement is necessarily slight. Examples of arthrodial joints are seen between the oblique processes of the vertebræ,[1] and the joints between some of the bones of the carpus and the tarsus.

THE SPHERICAL VARIETY OF DIARTHROSIS (ball-and-socket joint, or Enarthrodia). The convexity is marked in this form, and the concavity is smaller than it. Such a joint possesses many axes of rotation. It is with such that circumduction occurs. The hip and shoulder are examples of the spherical joint. It maintains on all sides an equal degree of motion.[2]

THE CYLINDRICAL VARIETY OF DIARTHROSIS.—The convexity in this division is broad and elliptical, and suggests the form of the condyle.

The cylindrical joints are divided into the (*a*) hinge joint or ginglymus; (*b*) the screw joint; and (*c*) the saddle joint.

(*a*) *The Hinge Joint* (ginglymus).—This is the best expression of a cylindroid joint. The axis of rotation is perpendicular to the axis of the moving bone, or, as in the case of the elbow, the axes of two bones, the radius and ulna, since both of these describe curvations round the axis of rotation.

The paths of movement of the hinge joint are free within certain limits. These degrees of freedom are of necessity fixed by the direction of the greatest convexity. The co-operation of the surfaces is exact.

(*b*) *The Screw Joint* (spiral joint).—In some facets of the more complex cylindrical joints the axis of the oblong convex surface falls obliquely to the axis of the concavity in which it plays. Such, for example, is the oblique facet on the inner condyle of the femur.

(*c*) *The Saddle Joint.*—This is so called from the resemblance its surfaces bear to those of a saddle. Each articular surface is convex in one direction, and concave in the opposite. The saddle joint is peculiar in presenting its apposed concave portion in such fashion as to tend to embrace the convexity of the proximal one. The saddle joint can be flexed, extended, abducted, and adducted, and, as a result of these varied movements, circumducted. It effects on the plan of the hinge joint the movements of a ball-

[1] For examination of tumors in position of flexion see Gross's System of Surgery, 5th ed. 1872, ii. 1065.

[1] Except the atlanto-axoid articulation, *q. v.*

[2] The terms of the above definition are doubtless not mathematically accurate. The term "spheroidal" is more exact than spherical. Of the two, the last-named is nevertheless preferred, since it is an equivalent of the term "ball-and-socket" in general use.

and-socket joint. The metacarpo-trapezoidal joint is the best example of a saddle joint in the body.

The conical variety of diarthrosis (pivot joint).—The convexity in this variety is in the form of a cone or disk, and clasped by a constricting ligament. Since in rotation the bone rolls upon its longitudinal axis, it is found that the axis of rotation of a conical joint agrees with that of the bone on whose periphery it occurs. Examples are seen in the superior radio-ulnar articulation, and in the atlanto-axoid articulation in part.

The composite variety of diarthrosis.—When the contrasts between the various facets of a joint are inconspicuous, it is said to be simple; when they are decided, it is said to be composite, since it combines in one the features of the spherical, the conical, or the cylindrical joint. A distinct motion is presumed to correlate with each well-defined facet or curvature.

When several kinds of curvature unite to produce a single motion, as, for example, when the rotary motion of the radius against the humerus unites with the hinge-motion of the ulna and humerus, or, as in the wrist, when the three convexities of the bones of the carpus correspond to the concavities of the surfaces yielded by the radius and the triangular ligament, the joint can be said to be *aggregated* (Meyer).

General Remarks on the Development of the Joints.—The differences between the methods of articulation already described are based upon the manner after which the bones are developed.

It will be remembered that the bones of the sides and vertex of the brain-case, and some of the bones of the face, develop from fibrous tissue (p. 97); such bones are connected by intervals of unossified membrane of varying width, and in time they unite by sutures which are so adapted as to permit of the increase in size of the brain, and the proper formation of the chambers of the face, without impairing the strength of the skull. When the growth of these structures is complete, the sutures, as a rule, disappear. This variety of union is called by the older writers *Syndesmosis*, the bones being joined by fibrous tissue, which in this sense is functionally the same as ligament, except that the tissue is continuous with the bed or plane of each bone, instead of being adjusted on the sides.

In the event of a joint arising between two of a series of cartilage bones, there exists, as in the above variety, an unossified interval which is continuous with the opposed ends of the bones. But this intervening tissue, instead of remaining undifferentiated, is developed either into cartilage or fibro-cartilage. Should the development be arrested at this stage, and the mediating tissue be cartilage, the variety of union known as *Synchondrosis* occurs, an example of which is seen between the sphenoid and the occipital bones.

If the mediating tissue be fibro-cartilage, *Symphysis* occurs, as is seen in the intervertebral and interpubic joints.

Should the ends of the bones develop layers of cartilage, and the intervening fibro-cartilage be parted therefrom by synovial membrane, and its own synovial surfaces be separated from one another, the form of joint arises such as is seen in the claviculo-sternal, the temporo-maxillary, and the carpo-ulnar joints.

If the fibro-cartilage is rudimentary, and attached only to the capsular ligament, and the synovia-bearing surfaces are continuous with one another, the form of joint seen at the knee is recognized.

If after the ends of the bones are furnished with cartilage, the fibro-cartilage is absorbed save a small band in the centre, the form of joint seen in the costo-vertebral and the ilio-femoral articulations arises. At least one of the crucial ligaments of the knee may be looked upon as the persistent central portion of the same primordial fibro-cartilaginous tissue which also remains on the sides of the joints in the former as interarticular disks.

If the mediating cartilage and fibro-cartilage entirely disappear, the form of movable joint exemplified in the elbow or the shoulder is seen.

The degree of possible influence exerted by muscle in effecting the evolution of the various forms of joints has as yet not been determined. It may be more than a coincidence that arrest of development at the stage of symphysis is seen in localities where comparatively slight motion occurs, as in the vertebral column and pubis; while localities in which the true synovia-secreting joints are seen are moved freely by highly specialized and powerful muscles. Bernays[1] does not credit muscle with any primal influence, since he found in the knee-joint that the synovial membrane developed, and the essentials of the joint surfaces appeared before the joint became movable. It is at a later period only in his judgment that the influence of irregular muscular action is at all felt. J. Cunningham,[2] however, in endeavor-

[1] Morph. Jahrbuch, 1878, Heft 3, p. 403.
[2] Journ. Anat. and Phys., 1878, p. 88

ing to explain how an adventitious synchondrosis has eventually become developed into a diarthrodic joint, assumes that it has been accomplished by the traction of muscles. He found that among examples of detached epiphyseal centres of the vertebræ some were attached to the main bone by synchondrosis, and some by diarthrodia, and that the latter variety existed where there was the greatest indirect motion due to muscular action.[1]

C. H. Hueter[2] has written several suggestive papers on the peculiarities of the articular surfaces of the bones in the child and the adolescent. These papers have important bearings upon the subject of congenital deformity, and indirectly upon the etiology of all obscure lesions of joint surfaces of limbs. By reason of the difficulty presented in an attempt to epitomize Hueter's elaborate statements, the reader is referred to the original.

List of authorities consulted in preparing the above section.

An Introduction to Human Anatomy, etc., Wm. Turner, Prof. of Anat. in Univ. of Edinburgh, Edinburgh, 1867.—See also article "Anatomy," Encycl. Brit. 9th ed.

Lehrbuch der Anatomie des Menschen, G. Hermann Meyer, Leipzig, 1873.

Article "Articulations," Prof. Todd, Encycl. Anat. and Phys., Vol. I.

Der Bau des Menschlichen Körpers, etc., Prof. Chas. Aeby, Leipzig, 1871.

THE JOINTS AND LIGAMENTS OF THE TRUNK.

The Joints and Ligaments of the Trunk are arranged as follows:—

Those of the Vertebral Column.
Those of the Lower Jaw.
Those of the Thorax.

The Joints and Ligaments of the Vertebral Column.

The Ligaments of the Vertebral Column are arranged for convenience into—

(1) The General Vertebral Ligaments.

(2) The Special Ligaments of the Atlas, the Axis, and the Occiput.

[1] For an elaborate and experimental paper upon the capacities of the joints, the modifications of shapes, and position of the same as dependent upon distension, see Ed. Albert, in Stricker's Med. Jahrbücher, 1873, p. 304.

[2] Virchow's Archiv, 1863.

(1) The General Vertebral Ligaments. These are eight in number, as follows:—

The Intervertebral Disks.
The Anterior Vertebral Ligament.
The Posterior Vertebral Ligament.
The Interspinous Ligament.
The Supraspinous Ligament.
The Intertransverse Ligament.
The Ligamenta Subflava.
The Ligamentum Nuchæ.

The Intervertebral Disks or Cartilages (fig. 1, Plate XXXVI., fig. 2, Plate XXXVII.) connect the bodies of the vertebræ together from the axis downward. The general form of each disk answers to the shape of the bodies of the vertebræ between which it is placed. In addition to uniting the vertebræ, the disks aid in defining the intervertebral foramina, and, in the dorsal vertebræ, the facets which articulate with the ribs. The disks are narrowest between the third to the seventh dorsal vertebræ and between the bones of the coccyx. Each disk is composed of a laminated exterior and a pulpy interior. The former portion makes up a little more than one-half of the entire disk. The pulpy portion is susceptible of great change in form. Thus, when the bodies of a pair of adjoined vertebræ are divided transversely through the middle, it arises above the plane of the section.

The peripheral fibres are composed of concentric layers of fibrous tissue and fibro-cartilage. These layers are arranged nearly vertically laterally, but are slightly curved as they approach the median line. Each layer is composed in such a way of oblique alternating fibres that successive arrangements of crossing fibres are seen. The pulp is placed a little nearer to the posterior than to the anterior border. Sometimes, according to Luschka, it sends a bud-like prolongation backward to the vertebral canal. Composed as it is of a loose stroma of fibrous tissue, holding in its meshes cartilage cells of various sizes, the pulp is thought to represent in the adult skeleton survivals of the chorda dorsalis, and to serve the purpose—under the great pressure to which it is subjected—of a ball or pivot held by stout peripheral fibres within the apposed axial surfaces of the bodies of the vertebræ.

In the cervical and the lumbar region the disks are thicker in front than behind. In the cervical region they about equal the thickness of the body of the vertebræ. In the dorsal region the disks are a little thicker behind than in front. The disk is the same height both before and behind at the junction

of the cervical and the dorsal and the dorsal and lumbar vertebræ. It is estimated that the length of the intervertebral disks equals about one-fourth of the entire length of the spine.

Relations.—The disks in front are in relation with the anterior vertebral ligament, and by many muscles, such as the Rectus Capitis Anticus Major, the Longus Colli, the Diaphragm, and the Psoas Magnus, and behind with the posterior ligament, with which they more intimately unite than with the anterior. Upon the sides in the neck they are in connection with the Intertransversalis muscles; in the dorsal region with the heads of the ribs; in the lumbar region with the vessels and nerves which traverse the intervertebral foramina.

Remarks.—According to W. Adams,[1] ulceration of the intervertebral cartilages is a not unfrequent lesion in Pott's disease, and may exist independently of vertebral necrosis. From the examination of several cases of spinal disease in the early stages, and from the study of specimens in the London Museum, Mr. Adams concludes that in the majority of instances of destructive disease of the spine, the affection commences in ulceration of one or more of the intervertebral fibro-cartilages, and generally in the central portions of the disk. The disease from first to last is sometimes limited to the intervertebral substance.

The Anterior Vertebral Ligament (figs. 1 and 4, Plate XXXVI., fig. 1, Plate XXXVII.) extends along the front of the vertebral column from the axis to the second sacral vertebra. Straight above, it increases in breadth as it descends to a point opposite the dorsal vertebræ, where it forms, in addition to the central fasciculus, two lateral portions, which, however, are thin and present numerous openings for the passage of vessels. The ligament adheres anteriorly to the bones at such places, and throughout is firmly attached to the intervertebral disks. In minute structure the ligament displays three distinct layers of fibres. The deepest are the shortest, and pass across each disk to the adjacent bodies of the vertebræ. The next pass from one bone to the third beyond, while the most superficial arise from one bone to be inserted in the third or fourth beyond.

In the neck the anterior vertebral ligament appears as a shining line between the Longus Colli muscles. In front lie the pharynx and œsophagus. Within the thorax, the azygos vein, the thoracic duct, the descending aorta, and the vena cava lie upon the ligament. Opposite the lumbar vertebræ the crura of the Diaphragm and the Psoas muscle are attached to it.

The Posterior Vertebral Ligament (fig. 1, Plate XXXVII.), thinner than the anterior, extends along the posterior surface of the bodies of the vertebræ, from the basilar process of the occipital bone to the lower lumbar vertebræ or even to the coccyx. It is broader above than below. Within the region of the neck it is spread evenly over the bodies of the vertebral disks, and is thus of exceptional strength; but through the rest of its position it expands over the disks, but contracts upon the borders of the vertebræ opposite the pedicles, so that viewed as a whole it presents a festooned appearance. Above it is adherent to the dura mater. Elsewhere it is distinct, and permits the vertebral veins to lie between it and the bone. Sappey states that it possesses more elastic tissue than does the anterior ligament. The minute arrangement of the fibres is essentially the same as in the anterior vertebral ligament.

Remarks.—Both the anterior and the posterior vertebral ligaments are of great strength, and aid in limiting the motions of the vertebral column. Thus the anterior ligament acts as a check to extreme backward motion, as the posterior ligament prevents extreme forward motion. It is probable that after displacement of an intervertebral disk the ligaments in question may prove to be capable of modifying the degree of dislocation of the contiguous vertebral bodies. Especially is this likely to be the case where the ligaments are of unusual strength.

The Interspinous Ligaments (fig. 2, Plate XXXVII.) are thin membranous bands which unite the spines, from the root to near the apices, of all the vertebræ from the seventh cervical to the sacrum. They are the least developed in the dorsal region, but are thick and quadrangular in the lumbar.

The Supraspinous Ligament extends between the summits of the spines of the vertebræ posteriorly to the interspinous ligaments with which it is continuous. In the neck it is thought to be represented by the ligamentum nuchæ. The ligament is best developed in the lumbar region, where it assists in closing the spinal canal. It is connected by numerous points of contact with the Erector Spinæ muscle. According to Quain, its posterior fibres pass downward from a given vertebra to a distance answering to the third or fourth vertebra below; those more deeply situated reach only from one to the next or the second below.

[1] Tr. Path. Soc. Lond., v. 1854, 243.

The Intertransverse Ligaments are bands extending between the transverse and the oblique processes of the vertebræ. They are best seen in the lower dorsal and the lumbar vertebræ. They are rudimentary in the rest of the dorsal vertebræ, and rudimentary or absent in the cervical region where their places are taken by the Intertransverse muscles.

The Ligamenta Subflava (fig. 2, Plate XXXVII.) are composed entirely of compact elastic tissue. They lie between the laminæ and, in part, the oblique processes of the vertebræ from the axis to the sacrum, in such manner as to be seen to the best advantage from in front. Each ligament is attached a little in advance of the lower edge of the lamina above and to the posterior surface of the lamina below. It follows that the fibres composing it are not vertical, but are inclined a little downward and backward, and that the height of the ligament is slightly in excess of the space between the pair of laminæ it unites. The ligaments slightly diminish in size from above downward, but are thicker in the loins than elsewhere. Each ligament is stoutest near the base of the lamina, but slightly increases in breadth toward the spine, where it forms a continuous band, pierced by several minute nerves. The fibres are more or less continuous with those of the interspinous ligaments. Between each ligament and the dura mater are interspersed a little cellular tissue and a few veins.

The ligamenta subflava assist the erector muscles of the spine in maintaining the erect position of the spine, and in recovering this position from one of forced flexion.

The Ligamentum Nuchæ extends upwards from the spines of the cervical vertebræ, and is attached above to the occipital bone. It is composed of two parts: the superficial part extends from the spine of the seventh cervical vertebra to the occipital protuberance; and the deeper part is formed by the union of the successive bands which arise from the remaining cervical spines, including the posterior tubercle of the atlas, and is attached to the occipital crest.—The ligamentum nuchæ serves as an intermuscular septum between the right and the left sets of muscles of the back of the neck, and aids in a minor degree in supporting the head. It is the rudiment of the more pronounced elastic ligament of quadrupeds. Its upper portion may be felt in the living subject when the head is forcibly flexed upon the neck. According to Luschka, the ligamentum nuchæ restricts abscesses of the back of the neck to their own side of the median line.

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(2) The Special Ligaments of the Atlas, the Axis, and the Occiput are nine in number, as follows:—

The Transverse Ligament.
The Posterior Atlanto-Axoid Ligament.
The Capsular Ligaments.
The Synovial Sacs.
The Anterior Atlanto-Axoid Ligament.
The Posterior Occipito-Atlantal Ligament.
The Occipito-Axoid Ligament.
The Anterior Occipito-Atlantal Ligament.
The Odontoid or Check Ligament.

The Transverse Ligament (figs. 2 and 3, Plate XXXVI.) extends across the central space inclosed by the atlas, and is attached by its extremities to the inclined roughened surface on the inner side of each lateral mass. It divides the space into two parts: an anterior third for the reception of the odontoid process of the axis; and a posterior third for the spinal cord and membranes. The ligament is thick, and slightly concave forward and convex backward, and from this circumstance has been termed by some authors the *semilunar* or *semicircular ligament*. It has been described by others as pitcher-shaped, the lip flange being in contact with the head of the odontoid process, while the lower vertical part embraces the

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EXPLANATION OF PLATE XXXVI.

Fig. 1. Articulation of the bodies of the vertebræ.

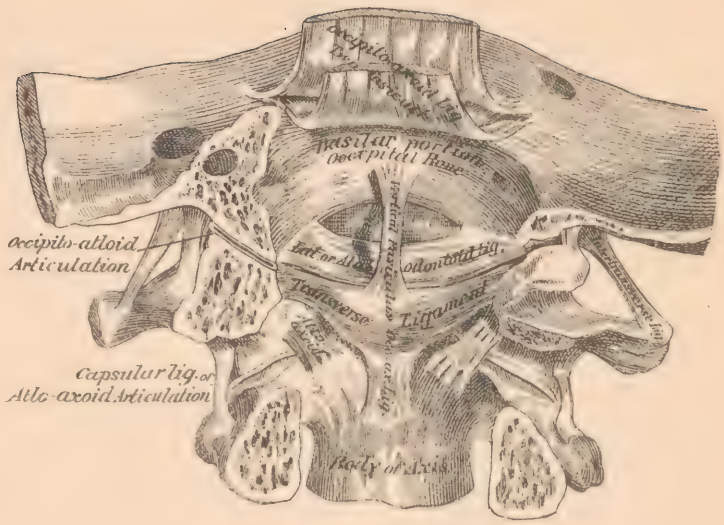
Fig. 2. Section of the occipital bone, the atlas and the axis seen from behind, showing the articulation of the head with the atlas and the axis.

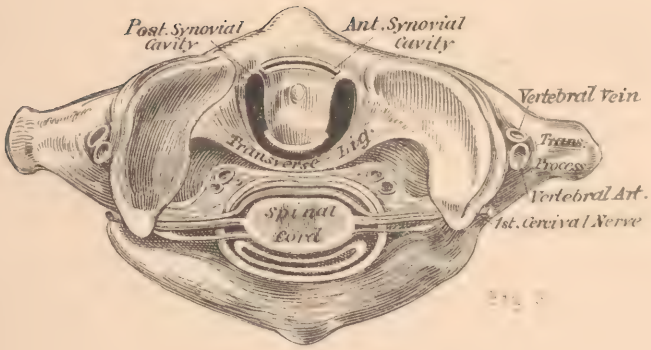
Fig. 3. The atlas, showing the contents of the vertebral canal and joint between the odontoid process of the axis and the atlas.

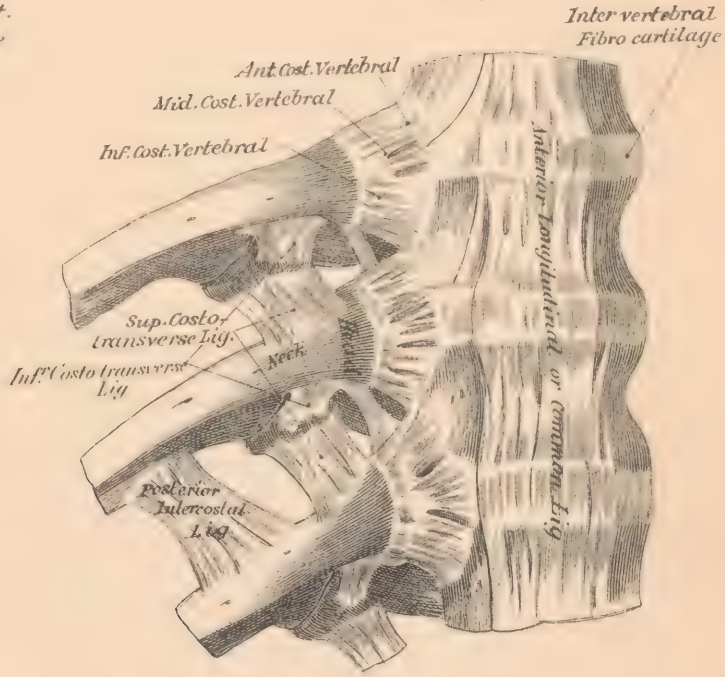
Fig. 4. A portion of the bodies of the vertebræ, with the vertebral ends of the ribs in position, showing the anterior vertebral and the costo-vertebral ligaments.

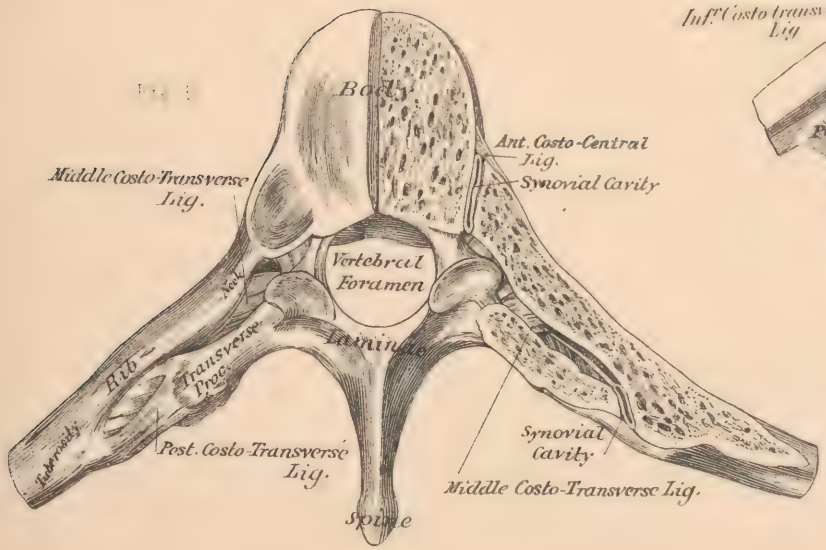
Fig. 5. A dorsal vertebra and portion of adjacent ribs, showing the costo-sternal ligaments.











J. Sinclair & Son. Lith.

neck of the process. The posterior surface of the odontoid process is covered with cartilage for action with the anterior surface of the ligament. Extending from the upper part of the ligament to the occipital bone is a small vertical bundle of fibres, and downward from the ligament to the body of the axis a second bundle. These make, together with the transverse ligament, a cross-like structure, which has received the name of the *crucial ligament.*

Remarks.—According to Sappey, the odontoid process is held lightly within the grasp of the transverse ligament, so that if the other structures uniting the atlas and the axis are removed, the process can be inserted and withdrawn with ease.

Luschka regards the transverse ligament as representing in part the unossified vertebra of the atlas. Should this view be accepted, the vertical ligaments above described may be considered as continuations of the posterior vertebral ligament.

The Posterior Atlanto-Axoid Ligament (fig. 2, Plate XXXVI.) extends from the inferior border of the posterior arch of the atlas to the superior border and spine of the axis. The superficial portion is fibrous, and corresponds to the interspinous ligament of the lower vertebræ. The deeper portions contain elastic tissue, and are thought to be rudiments of the ligamenta subflava.

The Capsular Ligaments (fig. 1, Plate XXXVII.) occupy the interval between the occiput and the atlas, and between the atlas and the axis. They are simple environments of the articular surfaces with fibrous membrane, and do not differ from analogous joints elsewhere. They are least developed on the side toward the vertebral canal. The anterior occipito-atlantal articulation is strengthened by the lateral fibres of the posterior occipito-atlantal ligament.

The Synovial Sacs. One of these exists between the odontoid process and the atlas, and another between the posterior surface of the same process and the transverse ligament.

The Anterior Atlanto-Axoid Ligament is a thin membranous structure extending between the lower border of the anterior arch of the atlas and the upper border of the body of the axis.

The Posterior Occipito-Atlantal Ligament extends from the posterior and the lateral margins of the foramen magnum to the upper border of the posterior arch of the atlas, where midway between the occipital crest and the occipital condyle a tubercle of attachment is seen. Its deeper parts are continuous with the dura mater. The ligament extends between the posterior and the lateral margins of the foramen magnum and the upper border of the posterior arch of the atlas. Its lateral portions are attached above to the tubercle which is seen about midway between the occipital crest and the occipital condyle, and below to the posterior edge of the superior articular surface of the atlas. Toward the middle line the ligament closes in the vertebral canal. This portion is made tense when the head is flexed.

The Occipito-Axoid Ligament (fig. 2, Plate XXXVI.) is a broad membranous structure extending between the anterior margin of the foramen magnum and the body of the axis. It is in close connection with the dura mater above, and is continuous with the posterior vertebral ligament below. Between it and the crucial ligament lies a small plexus of veins. A few of the fibres of the occipito-axoid ligament may serve to strengthen the transverse ligament of the atlas.

The Anterior Occipito-Atlantal Ligament consists of a firm, strong membrane, extending from the anterior margin of the foramen magnum to the upper margin of the anterior arch of the atlas. It is strengthened in the middle by a distinct rounded band, which is attached to the anterior tubercle of the atlas. This is described by some writers as the *anterior cervical ligament*, and is supposed by them to be the beginning of the anterior vertebral ligament. The ligament is pierced by the vertebral artery.

The Odontoid (Check, Lateral, Alar) Ligaments (fig. 2, Plate XXXVI.) are short, stout, oblique bands, which arise from the tubercle to the inner side of the occipital condyles. They pass downward and inward, and are inserted into the sides of the odontoid process. Occasionally the fibres intercross in front of the head of the process. Attached to the tip of the odontoid process is an unimportant band of fibres, which unites the axis to the anterior margin of the foramen magnum. It is designed chiefly to cover the space between the top of the atlas and the occipital bone. The closely united interlacing fibres constitute the transverse occipital ligament of Lauth.

The Temporo-Maxillary Joint.

The temporo-maxillary articulation (figs. 1, 2, 3, Plate XXXVIII.) is composed of the upper surface of

the condyloid process of the lower jaw, and that portion of the glenoid fossa in advance of the glenoid fissure, together with the articular eminence.

The condyle is held in position by a capsular ligament which is weak in front and at the inner side, but stout behind and to the outer side. A portion of the oblique outer fibres extending from the root of the zygoma to the neck of the jaw has received the name of the *external lateral ligament.*

Upon the inner side of the joint, but not related to it, is a loose, fascia-like band, extending from the spinous process of the sphenoid bone to the inner margin of the posterior dental foramen. This is called the *internal lateral ligament.* Between it and the lower jaw lie the internal maxillary artery and inferior dental nerve.

Within the joint are—

The Interarticular Disk.
The Synovial Sacs.

The Interarticular Disk is of an elliptical form, more broad than long. It is depressed toward the centre below, for the reception of the head of the lower jaw. Above it is depressed in front for the articular eminence, and is elevated behind for the glenoid fossa.

A Synovial Sac is situated one above and one below the disk. The former is the larger and looser of the two. Both sacs may communicate through an opening not unfrequently present in the centre of the disk. The *motions* of the temporo-maxillary articulation are a to-and-fro hinge-like motion, as seen in opening and shutting the mouth; and a lateral motion. In moderate antero-posterior movements the head lies within the glenoid fossa, but in pronounced depression of the lower jaw it glides forward upon the articular eminence.

The Joints and Ligaments of the Thorax.

Under the head of the joints and ligaments of the thorax are embraced—

The Costo-Vertebral Joints and Ligaments.
The Costo-Transverse Ligaments.
The Intercostal Joints and Ligaments.
The Costo-Sternal Joints and Ligaments.
The Sternal Ligaments.

The costo-vertebral joints and ligaments are of two kinds: those placed between the heads of the ribs and the bodies of the Vertebræ—the Costo-Vertebrals proper; and those placed between the angles of the ribs and the transverse processes of the Vertebræ—the Costo-Transverse.

The proper Costo-Vertebrals comprise—

The Anterior Costo-Vertebral.
The Capsular.
The Interarticular.
The Synovial Membrane.

The Anterior Costo-Vertebral (stellate ligament) (figs. 4, 5, Plate XXXVI.) protects the head of the rib from in front. It is attached to the head of the rib, and passes in a radiate manner therefrom to the bodies of the adjacent vertebræ and the intervertebral disk.

The *superior fascicle* (proper anterior costal) is attached to the body of the vertebra above; the *middle* fascicle (middle costo-vertebral) to the intervertebral fibro-cartilage; and the *inferior fascicle* (inferior costo-vertebral) to the vertebra below.

The Capsular Ligament (fig. 5, Plate XXXVI.) is a delicate sac, inclosing the joint which unites the head of the rib and the vertebræ; it is attached to the anterior ligament, where it is stouter than elsewhere.

The Interarticular Ligament, absent in the first, eleventh, and twelfth ribs, extends from the ridge between the facets of the head of the rib to the intervertebral disk. While embraced within the capsule, the interarticular ligament is, properly speaking, not *within* the joint, since a Synovial Sac lies above it and another below it.

The costo-transverse ligaments embrace—

The Superior Costo-Transverse.
The Middle Costo-Transverse.
The Posterior Costo-Transverse.
The Capsular.
The Synovial Membrane.

EXPLANATION OF PLATE XXXVII.

Fig. 1. The basilar portion of the occipital bone—together with the atlas and the axis—showing the anterior vertebral ligament and two capsules opened.

Fig. 2. A sagittal section of the vertebral column and pelvis, showing the various intervertebral and pelvic ligaments.

Fig. 3. The sternum, the costal cartilages, and the sternal ends of the clavicles, showing the articular and ligamentous attachments.

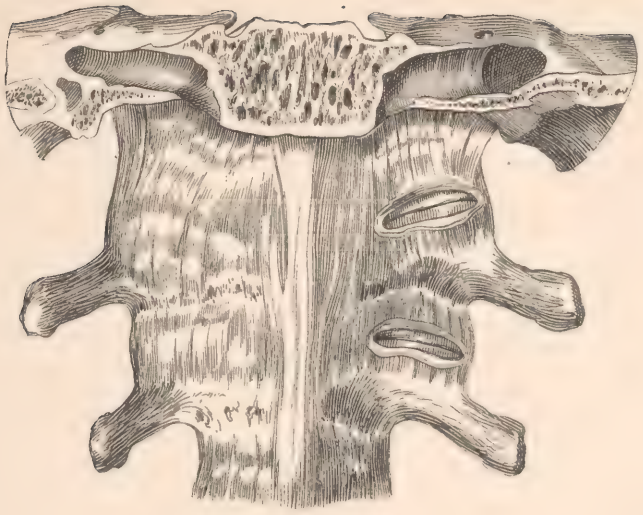


Fig 1

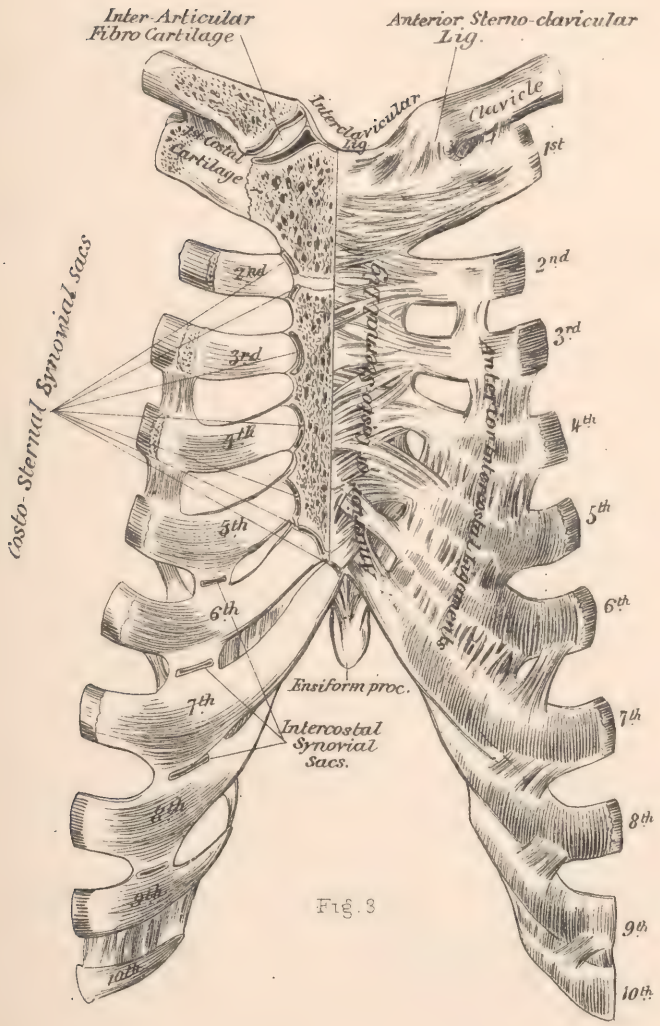


Fig. 3



Fig 2

T. Smclair & Son. Lith.

The Superior Costo-Transverse (anterior) (figs. 4, 5, Plate XXXVI.) is attached below to the upper border of the neck of the rib, and passes upward and outward to be attached to the under surface of the transverse process next above. It is broader than the inferior, and is absent in the first and the twelfth ribs.

The Inferior Costo-Transverse (middle interosseous) (figs. 4, 5, Plate XXXVI.) is attached to the lower border of the neck of the rib, and passes downward and slightly outward by short, stout fibres, to be attached to the anterior surface of the adjacent transverse process. It is rudimentary in the eleventh and twelfth ribs.

The Posterior Costo-Transverse passes from the tip of the transverse process to the tuberosity behind the facet of the rib in connection with it. This ligament is wanting in the eleventh and twelfth ribs.

The Capsular Ligaments unite the articular facets at the tuberosities of the first to the tenth ribs with the facets on the corresponding transverse processes.

Synovial Sacs. Each joint, as above defined, is lined by a simple, delicate synovial membrane (fig. 5, Plate XXXVI).

THE INTERCOSTAL JOINTS AND LIGAMENTS are as follows:—

The Posterior Intercostals.
The Anterior Intercostals.
The Synovial Membranes.

The Posterior Intercostal Ligaments (fig. 4, Plate XXXVI.) are thin bands, passing between the ribs a short distance in advance of the tuberosities. The Anterior Intercostal ligaments connect the costal cartilages from the sixth to the eighth. The Synovial membranes (fig. 3, Plate XXXVII.) are confined to the region last named. They are inconstant, simple in character, and variable in form. Sometimes the cartilages at points answering to the synovial sacs are furnished with small facets.

THE COSTO-STERNAL JOINTS AND LIGAMENTS present the following structures:—

The Anterior Costo-Sternal.
The Posterior Costo-Sternal.
The Capsular.
The Synovial Membrane.

The Anterior Costo-Sternal Ligament is a broad, membranous expansion, passing from the sternal ends of the costal cartilages of both sides, from the first to the seventh, to the anterior surface of the sternum, where the fibres freely interlace. The ligament does not support the costo-sternal articulations, but protects the sternum from in front.

The Posterior Costo-Sternal Ligament is weaker than the anterior, and preserves to the posterior surface of the sternum the relations borne by the anterior costo-sternal ligament to the anterior surface. Special bands pass from the sixth and seventh costal cartilages to the ensiform cartilages.

The Capsular Ligaments, usually described as enclosing the synovial membranes placed between the sternal ends of the costal cartilages and the sternum, are, properly speaking, portions of the anterior and posterior costo-sternal ligaments. Both the synovial membrane and the capsule are absent, as a rule, in the first costal cartilage.

The Synovial Membranes at the second costo-sternal junction are two in number—one above, and the other beneath the ligamentous structure extending from a central ridge on the sternal end of the cartilage to the line of junction between the manubrium and the gladiolus. The remaining synovial cartilages intervene between the ends of the third to the seventh costal cartilages and the sides of the manubrium.

Under the head of THE STERNAL LIGAMENTS systematic writers describe special bands of the anterior and the posterior costo-sternal ligaments that unite the manubrium and the gladiolus before the ossification of the sternum is complete. They do not require separate descriptions.

THE LIGAMENTS OF THE SUPERIOR EXTREMITY.

The Ligaments of the Superior Extremity are arranged in the following groups:—

The Clavicular-Sternal Joint and Ligaments.
The Joint and Ligaments of the Shoulder.
The Elbow-Joint and Ligaments.
The Ligaments of the Radius and Ulna.
The Wrist-Joint and Ligaments.
The Ligaments of the Hand.

THE CLAVICULO-STERNAL JOINTS AND LIGAMENTS.

The Clavicular-Sternal Joint is composed of the thoracic articular surfaces of the clavicle, the clavicular notch of the sternum, and the upper surface of the first rib. The ligaments holding the surfaces together are—

The Anterior Sterno-Clavicular.
The Posterior Sterno-Clavicular.
The Interarticular Fibro Cartilage.
The Synovial Membranes.

The accessory ligaments are—

The Interclavicular.

The Costo-Clavicular.

The Anterior Sterno-Clavicular Ligament is attached to the front and the upper part of the thoracic end of the clavicle, and passes obliquely downward and inward to the manubrium, and to a slight degree to the cartilage of the first rib. It increases in strength toward the interclavicular ligament with which it is continuous. Its upper fibres are in part contiguous to the clavicular fibres of the Sterno-Cleido-Mastoideus.

The Posterior Sterno-Clavicular Ligament is attached to the posterior and the lower portion of the thoracic end of the clavicle, and passes in a somewhat radiating manner to the sternum and the cartilage of the first rib.

The articular surfaces embraced by the above ligaments yield unusual features. Instead of presenting concavo-convex facets, they are so shaped that the transverse (frontal) diameter of the clavicle is adapted to the antero-posterior (sagittal) diameter of the sternum; both surfaces are more or less saddle-shaped, and the clavicular surface is the larger.[1] In order to make the surfaces in a degree coadaptive, the *Interarticular Fibro-cartilage* is interposed. This disk is of a subrounded shape, wider and thicker above than below, while thin in the centre. It is held more intimately to the clavicle than to the thorax, and is placed obliquely from the upper border of the bone, downward and outward to the cartilage of the first rib. Its anterior surface is convex from within outward, and slightly concave from before backward. It answers only to the upper two-thirds of the clavicular surface;—the lower triangular facet which rests on the first rib is ordinarily not in contact with it. The disk exhibits many varieties. It becomes thinned with old age, and may be perforated, or even absent.

The space between the disk and the sternum, and the space between it and the clavicle, are distinct; each is lined with a synovial membrane. The lateral cavity is much the more extensive of the two, is prolonged a short distance beneath the clavicle, and, as a rule, admits from beneath a synovial fold that corresponds in position with the costal surface of the bone. This portion of the joint may, indeed, be entirely separate from the rest.

The Interclavicular Ligament is a strong, coarsely-textured prismatic or flattened band extending across the supra-sternal notch between the sternal ends of the clavicles. At its ends the ligament is strengthened by slips which pass to the upper portion of the interarticular disk, and to the margin of the manubrium.

The Costo-Clavicular Ligament (rhomboid ligament) extends obliquely upward and backward from the upper margin of the first rib to the rough impression on the under surface of the clavicle near its thoracic end. It is strong, flat, and composed of oblique fibres. The ligament is covered by the Pectoralis Major muscle, and is stronger in the female than the male. The thin lateral edge is in relation with the median border of the Scalenus Anticus muscle.—It is subject to great variation. In rare instances Luschka has seen a process of bone take its place.

Fracture of the clavicle to the median side of the costo-clavicular ligament does not[1] prevent the outer fragment from passing forward.

Movements.—The movements of the sterno-clavicular articulation are of two kinds—one which partakes of the ill-defined but wide range seen in symphysis, and another more limited, which is seen in diarthrosis. The former exists between the axial surface of the clavicle and the sternum. The latter

[1] The clavicular surface is concave above and in the centre, but convex below, while the sternal is elongate transversely, concave from within outward, and a little convex from before backward.

[1] R. W. Smith, Dublin Journ. Med. Sci. 1870, 8.

EXPLANATION OF PLATE XXXVIII.

Fig. 1. Sagittal section of the temporal and inferior maxillary bones, showing a similar section of the temporo-maxillary joint.

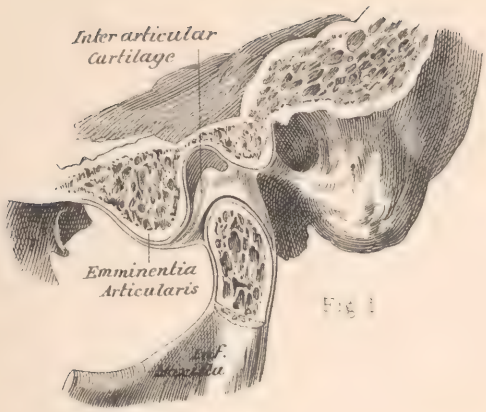
Fig. 2. Portions of the same, showing the temporo-maxillary joint from without, as well as the ligamentous attachment between the skull and the hyoid bone.

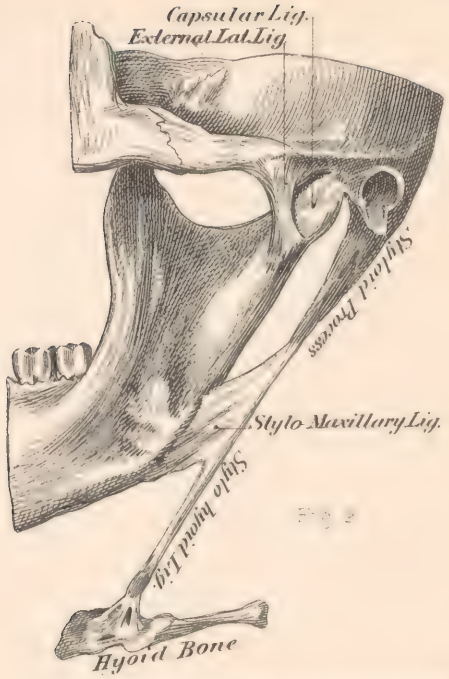
Fig. 3. The same from within, omitting the cranio-hyoid attachment.

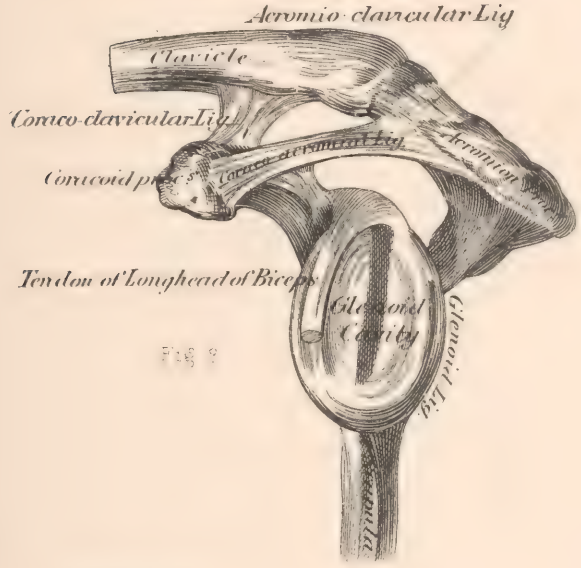
Fig. 4. The scapular ligaments and the claviculo-scapular attachment.

Fig. 5. The same, viewed from in front, together with an anterior view of the shoulder-joint.

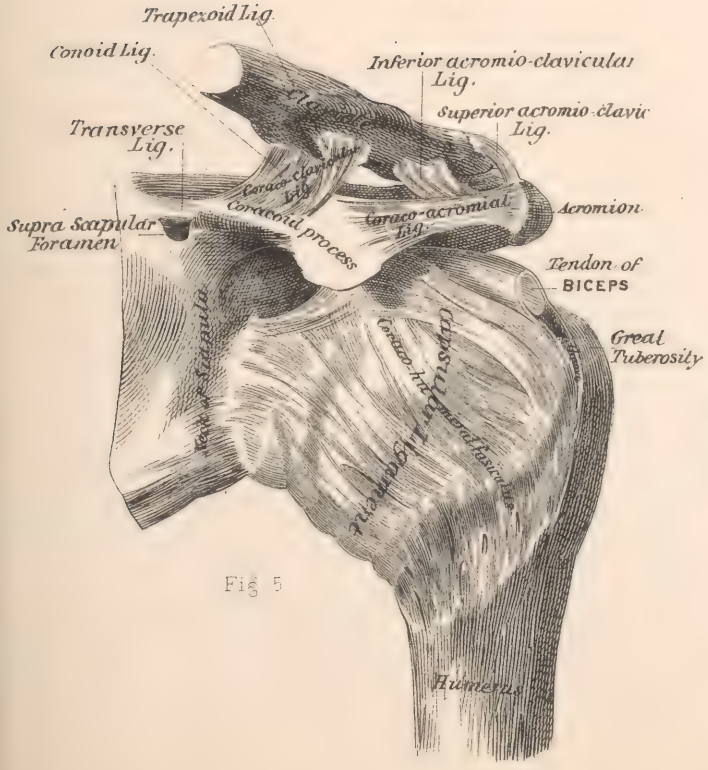
Fig. 6. Sagittal section of the shoulder-joint.

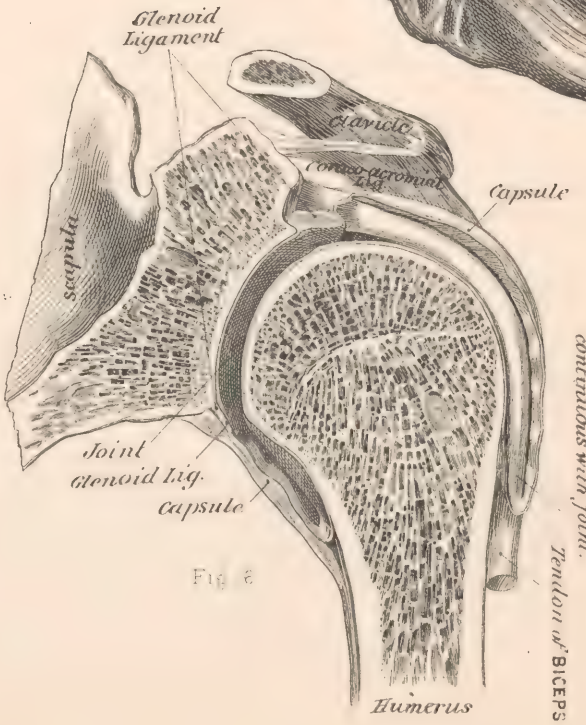












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exists between the inferior portion of the thoracic end and the first rib. The symphyseal motion is capable of assuming, under some conditions, a great degree of latitude, owing to the mobility of the interarticular disk. It would be brought greatly into play in the act of swimming. The diarthrodial movements are determined by the actions of the muscles that depress and draw forward or backward the clavicle, as following the forced action of the Pectoralis Major, the Latissimus Dorsi, etc. The movements of symphysis are in a measure checked by the interarticular ligament, while those of diarthrosis are checked by the costo-clavicular ligament.

The claviculo-sternal articulations are of great strength, since upon the maintenance of the clavicle against the sternum depend the movements of the humerus. Luxation of this joint is infrequently seen. The bone may also be displaced upward and, more rarely, backward.

The Joint and Ligaments of the Shoulder.

The region of the shoulder includes the scapular end of the clavicle, the scapula, and the head, neck, and tuberosities of the humerus, together with the soft parts covering the above structures.

The ligaments and the joint structures are as follows:—

The Ligaments of the Scapula.
The Scapular attachments of the Clavicle.
The Shoulder-Joint.

THE LIGAMENTS OF THE SCAPULA.

The ligaments of the scapula are—

The Transverse.
The Acromio-Coracoid.
The Glenoid.

The Transverse Ligament is a delicate band of fibrous tissue, extending across the scapular notch. It arises from the base of the coracoid process, and it is inserted into the external edge of the upper border of the scapula. It consists, as a rule, of two fasciculi, one pertaining to the dorsal, the other to the ventral aspect of the notch.—Usually transverse, the fibres of this ligament may be oblique, and nearly parallel to the axillary border of the scapula, and in part continuous with the fibres of the conoid portion of the coraco-clavicular ligament.

The Acromio-Coracoid Ligament extends as a broad, somewhat triangular ligament between the lateral border of the coracoid process and the tip of the acromion. It is free and thick behind, but tapers in front where it is continuous with a thin layer of connective tissue underlying the Deltoid muscle. It is lost in the connective tissue over the infra-spinous fossa.—According to Henle, the posterior margin of this ligament passes over the supra-spinous fossa. Beneath, the ligament is loosely held to the tendon of the Supra-spinatus muscle and the capsule of the shoulder-joint. The upper surface, from which it is separated by a bursa, is covered by the Deltoid muscle. The outline of the ligament can be felt under the skin.

The acromio-coracoid ligament and the coracoid process and the acromion form a wide though low vault, against which the head of the humerus and the upper portion of the great tuberosity are held during the contraction of the Supra-spinatus muscle and the consequent elevation of the arm.

The Glenoid Ligament is a triangular rim of fibro-cartilage which surrounds the edges of the glenoid fossa. It is usually less thick below than above, where it is in intimate association with the tendon of the Biceps muscle. It is more prominent on the median as compared with the lateral edge, is of a yellow color, and composed of concentrically arranged fibres.

THE SCAPULAR ATTACHMENTS OF THE CLAVICLE.

These are two in number as follows:—

The Acromio-Clavicular Joint.
The Coraco-Clavicular Ligament.

The Acromio-Clavicular Joint.

The Acromio-Clavicular Joint consists of a diarthrodial joint situated between the clavicle and the acromion, and is composed of two obliquely placed opposed facets, the upper of which is derived from the clavicle. Both surfaces are covered with a thin layer of fibro-cartilage. It is subject to much variation in form, and is best developed in muscular individuals.

It presents for examination the following structures:—

The Superior Acromio-Clavicular Ligament.
The Inferior Acromio-Clavicular Ligament.
The Interarticular Fibro-Cartilage.
The Synovial Membrane.

The Superior Acromio-Clavicular Ligament consists of straight fibres extending from the lateral end of the clavicle to the median side of the acromion.

The Inferior Acromio-Clavicular Ligament extends between corresponding points with the superior, and does not require separate description. Some writers

describe the ligaments of the acromio-clavicular joint as constituting a true capsule. Since the facet occupies the posterior part of the scapular portion of the clavicle only, it follows that the ligamentous tissue in advance of the facet is entirely distinct from the joint.—The capsule is composed of a number of straight fibres, embracing the facets, and extending from the lateral end of the clavicle to the median side of the acromion. It is much thicker above than below.

The Interarticular Fibro-Cartilage is rudimental. The capsule sends the disk inward from its under surface. It is rarely sufficiently large to separate entirely the joint surfaces, and may be absent.

The Synovial Membrane resembles the membrane found in other joints. When the interarticular fibro-cartilage is complete, two sacs are formed.

Dislocation of the scapular end of the clavicle is exceedingly difficult to reduce.

The Coraco-Clavicular Ligament.

The Coraco-Clavicular Ligament extends from the clavicle at and near the conoid tubercle to the coracoid process. It is composed of two portions—the conoid and the trapezoid, which are often spoken of as distinct ligaments. The two portions are more or less continuous on the coracoid process, as they converge from the clavicular attachments. The *conoid portion* (conoid ligament) is nearly vertical, and is placed somewhat behind and to the median side of the trapezoid. It is more or less triangular in form, and extends between the conoid tubercle and the posterior border of the scapular end of the clavicle downward, to be attached to the median side of the base of the coracoid process directly in front of the scapular notch. It oftentimes receives a small fascicle from the sheath of the Subclavius muscle. The *trapezoid portion* (trapezoid ligament) extends obliquely from the clavicle downward and inward. It is placed somewhat in front and to the lateral side of the conoid portion, and is attached above to the clavicle from the oblique line on the under surface of the scapular end of the clavicle, and below to the rough surface of the median border of the base of the coracoid process. A bursa is often found between the two ligaments. The subclavicular groove extends a short distance between them.

Movements.—In the acromio-clavicular joint the clavicular facet and the inter-articular disk are relatively fixed; while the scapular facet is circumducted, and responds to all the motions of the scapula. The coraco-clavicular ligament acts as a check to rotation of the scapula, and indirectly relieves the joint from strain. The acromio-coracoid ligament also relieves it, as in the acts of creeping and in pushing downward.

THE SHOULDER JOINT.

The shoulder-joint (scapulo-humeral joint) represents the contact of the head of the bone against the glenoid cavity of the scapula. Both the surfaces are covered with cartilage. That on the humerus is thickest in the middle, and thinnest at the sides; that of the glenoid cavity is thinnest in the middle, and thickest at the sides.

The ligaments of the shoulder-joint are—

The Capsular Ligament.
The Coraco-Humeral Ligament.
The Synovial Membrane.

The Capsular Ligament is a loose capsule of fibrous tissue attached to the neck of the scapula just beyond the brim of the glenoid cavity above, and to the neck of the humerus below. It is notably strengthened externally by a band arising from the base of the coracoid process, and directed toward the greater tuberosity of the humerus, known under the name of the *coraco-humeral ligament*, and in a less degree by the tendons of the Supra-spinatus, the Infra-spinatus, and the Subscapularis muscles. The two muscles last named are remarkable for the intimate manner in which the fibres of the capsule are associated with them. The capsule is weakened at the point of union, and may be defective, as in the instance where the tendon of the Subscapularis and that of the Infra-spinatus lie in contact with it.—The ligament forms a loose vertical fold at the inner side of the neck of the humerus when the arm is in repose. This fold is, however, obliterated when the arm is elevated.—The capsule is sufficiently capacious to hold a body much larger than that of the head of the humerus, and requires the sustained action of the muscles about the joint to keep the head of the bone in position. It is supported within by the long head of the Biceps muscle, which passes over the head of the humerus, and which serves to give it support by the pressure exerted from below upward. It is further strengthened from without by the position of the coracoid process, the acromion, and the coraco-acromial ligament.

The Synovial Membrane of the shoulder-joint sends short prolongations along the course of the Infra-spinatus and the Subscapularis muscles and the defective places in the capsule. A third *cul-de-sac* passes along the entire length of the bicipital groove of the humerus, which is inclosed by a transverse fibrous

band above, and by the fibrous extension of the tendons of the Latissimus Dorsi and the Teres Major muscle at the floor and sides. A delicate fold of the synovial membrane assists the long head of the Biceps muscle in retaining its position in the bicipital groove. Humphry says that the head of the humerus in dislocation of the shoulder is sometimes received within the bulging *cul-de-sac* of the synovial membrane under the Subscapularis.

The Arteries of the joint are branches of the anterior and the posterior circumflex and suprascapular.

The Nerves are branches of the circumflex and the suprascapular.

Remarks.—The movements of the shoulder-joint are so combined with the functions of the shoulder muscle that it is impossible to disassociate them. The chief agency, here as in other diarthrodia, in the maintenance of contact between the humerus and the scapula, is atmospheric pressure. Marked rotation of the humerus outward in the subject will cause separation of the surfaces, when the head of the humerus will fall away from the scapula. Rotation of the arm inward restores the normal contact between the two. This observation, made on the authority of Henke, may be received with a single qualifying fact, that the description is known to be true of the dead subject only.—It is more than probable, even if the original non-elastic muscles about the joint interfere with their physiological uses in maintaining contact, that inward rotation is in many features distinct from outward rotation. The outer (lateral) half of the head of the humerus when covered with cartilage differs from the median. The former is the more convex side of the surface, and ends abruptly at the anatomical neck; the latter, in addition to being flatter, ends imperceptibly at the neck, and is continuous at its borders with the capsule. The line separating these two surfaces is well defined by the coraco-humeral ligament, which answers to the greatest length of the head of the humerus obliquely downward and outward. On the posterior surface of the joint the scapular head of the Triceps lies nearly in a similar line. The muscles strengthening the joint and assisting in maintaining contact are, apart from the scapular muscles proper, the Deltoid, the Biceps, the Coraco-brachialis, the Triceps, and upper part of the Serratus Magnus. Unaided contraction of the Deltoid tilts the head of the humerus downward from the glenoid cavity—in which action the Serratus Magnus and the Pectoralis Major assist.[1]

[1] Duchenne, Physiologie des Mouvements.

The joint is strengthened in such movements by the Coraco-Brachialis, and the scapular head of the Triceps.

For the mechanism between the humerus and the acromion, see W. Ruge.[1]

The Costo-scapular Joint. Under this head Luschka[2] has described a bursa-like joint between the scapula and the third and fourth ribs of the left side. R. Hesse[3] gives a case in illustration of the presence of this joint in a man aged twenty-three, who complained of a grating sensation in moving the left arm, and of slight pain at the junction of the second and third ribs with the sternum. Noisy crepitation was readily observed upon motion of the scapula.

Remarks.—The coraco-clavicular ligament is of enormous strength. It limits rotation of the scapula forward and inward, and is the chief agency by which elevation of the scapula is effected by muscles inserted into the clavicle, namely, the Sterno-Cleido-Mastoid and the Trapezius.

The Elbow-joint and Ligaments.

The parts entering into the elbow-joint are the trochlear surface and the radial head of the humerus, the greater and lesser sigmoid cavities of the ulna, and the head and the neck of the radius. These parts are inclosed in a common capsular ligament which is notably thickened at the sides; but it is thin both in front and behind, and is intimately attached to the annular ligament holding the head of the radius in position.

The parts to be studied, therefore, at the elbow-joint are—

The Capsular Ligament.
The Internal Lateral Ligament.
The External Lateral Ligament.
The Orbicular Ligament.
The Synovial Membrane.

The Capsular Ligament is very loose, though on the whole thin and of varying thickness. It extends in front from above the coronoid fossa to the coronoid process and the annular ligament, and behind from above the olecranon fossa to the olecranon. Anteriorly it is stronger at the middle than at the sides, and is covered by the Brachialis-Anticus muscle. Behind it is relatively strong above the tip of the olecranon, but very weak and bursa-like at the side, where it is composed of transverse fibres extending from the ole-

[1] Zeit. für Rat. Med., 1859, 258.
[2] Prager Vierteljahrschr., cvii. 1870.
[3] N. Y. Med. Journ., 1871, 730.

cranon to the lateral margins of the humerus. The interstices between the ulna and radius are filled with fat.

The Internal Lateral Ligament is composed of two fasciculi of diverging fibres, — an anterior and a posterior. The *anterior fasciculus*, the stronger and more superficial of the two, extends between the anterior surface of the epitrochlea and the inner margin of the coronoid process; it serves to limit extension. The *posterior fasciculus*, thin and radiated, extends from the posterior surface of the epitrochlea to the side of the olecranon, and serves to limit flexion. It is directly continuous with the capsule posteriorly. Between these two fasciculi is a minute foramen answering to the notch at the inner end of the transverse groove, which is filled with a pellet of fat. The internal lateral ligament is covered by the common flexor mass. The ulnar nerve is, in a measure, protected by an imperfect fibrous canal, which is covered by the ulnar fibres of origin of the Flexor Carpi Ulnaris muscle.

The External Lateral Ligament is an imperfectly defined thickened band of the capsule, extending from the epicondyle, and spread out over the orbicular ligament, which it holds in position. It is shorter than the internal. Posteriorly a number of its fibres are attached to the ulna. The external lateral ligament is covered by the origin of the common extensor mass, and yields points of origin for the Supinator Brevis muscle.

The Orbicular Ligament (annular, coronary ligament) is a strong ring-like band attached to the anterior and the posterior edges of the lesser sigmoid cavity. It is thicker behind than in front, and thinner above than below, where it ends at the neck of the radius. It describes four-fifths of a circle, and encompasses the vertical surface of the head of the radius. It is sustained by the fibres of the external lateral ligament and a portion of the anterior division of the capsule. At a point where these structures are divided, the annular ligament sinks to the position of the neck of the radius. According to Cruveilhier, the ligament is easily ruptured in front. In luxations it is not the external lateral, but rather the anterior portion of the orbicular ligament that is ruptured.

The Synovial Membrane lines the ulno-humeral as well as the radio-humeral surfaces. Morbid growths developed within the plicæ of this membrane may resemble movable cartilages. Luschka mentions a case in which a body of this kind placed in the olecranon fossa prevented full extension of the forearm.—The ulnar nerve lies so near the capsule that its section at this point cannot be attempted without endangering the integrity of the joint.

The Arteries are derived above from the communicating branch between the superior and the inferior profunda and the anastomotic branches of the brachial, and below from the recurrent branches of the radial and the ulnar arteries.

The Nerves of the elbow-joint are received posteriorly from a branch of the ulnar nerve, and anteriorly from a branch of the radial.

Movements.—The elbow-joint embraces two lines of movement: a movement of flexion and extension taking place between the trochlea of the humerus and the ulna; and a movement of rotation taking place between the radial head of the humerus, the orbicular ligament, and the head of the radius. The last-named portion of the joint enters into flexion and extension with that of the trochleo-ulnar movements. Flexion is checked by the coronoid process lying within the coronoid depression of the humerus.—Pronation and supination may be demonstrated in extreme flexion, when the motion occurs between the raised rim of the radial proximal surface and the depression above the radial head of the humerus.—Extension is checked by the olecranon lying within the olecranon fossa of the humerus. It is limited by about 180°.—Inward rotation is checked by the lateral border of the vertical surface of the radial head impinging against the anterior portion of the orbicular ligament.—Outward rotation is checked by the oblique ligament and by the median border of the radial head impinging against the orbicular ligament.

The lateral ligaments are of great importance in maintaining the integrity of all parts of the elbow-joint. The joint is destroyed, should one of them be divided.

The bones of the forearm do not coincide with the axis of the arm, either in flexion or in extension. In flexion they incline inward, and in extension outward. The latter inclination is most pronounced in supination. In applying an extending force to the forearm with a view of influencing the shoulder, it is recommended to pronate the hand. In this position the inclination of the forearm outward is measurably removed.[1]

The movements of flexion and extension are performed on paths that are held by H. Meyer[2] to be portions of a screw-like or spiral figure.

[1] Richet, Anat. Medico-Chirurg., 897.

[2] Arch. f. Anat. Physiol. und Wissensch. Med., 1866.

The Ligaments of the Radius and the Ulna.

The movements of pronation and supination take place between the radius and the hand as one factor, and the humerus and the ulna as the other.

The joints interested in the movements are—

The Humero-Radial.
The Superior Radio-Ulnar.
The Inferior Radio-Ulnar.

The Humero-Radial Joint (figs. 1 and 3, Plate XXXIX.) is a part of the elbow-joint, and has been already described.

The Superior Radio-Ulnar Joint exists between the convex circumferential vertical border of the head of the radius and the concave lesser sigmoid cavity of the ulna. The elbow-joint in great part defines it. It is strengthened by the orbicular and the oblique ligaments.

The Oblique Ligament is a stout band passing obliquely downward and outward from the region of the base of the coronoid process (tubercle) of the ulna to the radius a little distance below the tuberosity. It acts as a check to supination.

THE INTEROSSEOUS MEMBRANE.

The membrane stretching across the space between the radius and the ulna is called the *interosseous membrane*. It is attached by roughened borders, which are specially well marked at the upper portion. Aponeurotic in structure, the membrane is composed of thin fibres directed obliquely downward and inward, while its posterior surface is strengthened by fibres passing in the opposite direction. It imperfectly occupies the interosseous space, since it begins about an inch below the tubercle of the radius, and terminates a short distance above the wrist-joint. It is perforated at several points for the passage of small bloodvessels, and toward the lower border by a larger opening for the posterior interosseous artery.

The interosseous membrane assists the oblique ligament in checking supination. It also acts as an intermuscular septum between the muscles on the anterior and the posterior portion of the forearm.

THE INFERIOR RADIO-ULNAR JOINT.

The head of the ulna is held in the sigmoid cavity of the radius by the anterior and the posterior radio-ulnar ligaments. Between the free distal end of the ulna and the cuneiform bone a plate of fibro-cartilage is inserted.

The several parts of the joint, therefore, are—

The Anterior Radio-Ulnar Ligament.
The Posterior Radio-Ulnar Ligament.
The Fibro-Cartilage.
The Synovial Membrane.

The Anterior and the Posterior Radio-Ulnar Ligaments (figs. 2, 4, and 5, Plate XXXIX.) are straight and narrow bands extending on either side of the radio-ulnar articulation.

The Fibro-Cartilage is of a triangular form, placed transversely to the axis of the forearm. It is thick, and attached by its base to a ridge at the carpal side of the sigmoid of the radius; and by its small extremity to the notch between the head of the radius and the styloid process. It is thin at the sides and centre, where, indeed, it may be perforated, but thick at the apex and the circumference. The apex is a stout ligamentous structure by means of which the cartilage is attached to the ulna. It is concave on both sides—above for the head of the ulna, and below for the cuneiform bone.

The Synovial Membrane between the radius and the ulna is continuous with that between the fibro-cartilage and the head of the ulna. It is known as the *membrana sacciformis*, and is remarkable for containing a relatively large amount of synovial fluid.

The movements of pronation and supination do not affect the ulna when the elbow-joint is extended, but induce a slight rotatory motion, which is best marked at the distal end when the elbow is semi-flexed.

The Wrist-Joint.

The wrist-joint (radio-carpal) (figs. 2, 4, and 5, Plate XXXIX.) is formed by the distal end of the radius, together with the triangular fibro-cartilage articulating with the proximal surface of the first row of carpal bones.—The proximal factor of the wrist-joint is composed of the radius, which forms its outer two-thirds, and of the fibro-cartilage, which forms its inner third. The general surface is concave in both directions, and marked by three impressions: the outer for the scaphoid bone, the middle for the semi-lunar bone, and the inner for the cuneiform bone. The sides of the concavity are deepened by the styloid processes.—The distal factor is convex in both directions, with an inclination toward the dorsal surface. The joint embraces—

The Capsular Ligament.
The Internal Lateral Ligament.
The External Lateral Ligament.

The Capsular Ligament. The *anterior portion* of the capsular ligament is shorter toward the radial side, and stronger than the posterior. It extends from the lower border of the forearm to the first row of carpal bones — thence a slip is continued to the os magnum. — The *posterior portion* (rhomboid ligament) descends obliquely downward and outward to the first row of bones, the fibres notably converging toward the cuneiform bone.

The Internal Lateral Ligament passes as a firm cylindrical cord from the spinous process of the ulna to the cuneiform bone, at the same time sending fibres to the pisiform bone and the anterior annular ligament. It is partially covered by the Extensor Carpi Ulnaris muscle.

The External Lateral Ligament, stouter though less defined than the preceding, passes from the styloid process of the radius to the scaphoid bone, where it effects a broad attachment. It contributes to the composition of the anterior annular ligament, and thence is continued to the trapezium. Its lateral side is in relation with the Extensor Ossi Metacarpi Pollicis muscle.

The Synovial Membrane is loose behind. At times the cavity is continuous with the pisiform articulation, and at others, through the absence of one of the interosseus ligaments of the first row, with the intercarpal synovial sac.

The wrist-joint is in a line with the apex of the styloid process of the ulna.

The Joints and the Ligaments of the Hand.

These comprise—

The Joints and Ligaments of the Carpus.
Those of the Carpo-Metacarpal Joint.
Those of the Inter-Metacarpal Joints.
Those of the Metacarpo-Phalangeal Joints.
Those of the Inter-Phalangeal Joints.

The Joints and Ligaments of the Carpus include the structures uniting the bones in each row, and those that unite the two carpal rows.

The bones of the first row of the carpus are united on the dorsal surface by a ligament placed between the scaphoid and the semilunar bones, by one between the semilunar and the cuneiform, and by a third—an interosseous ligament—placed near the dorsal surface, and uniting the last-named bones.

On the palmar surface the bones are united by three bands, stretching from the scaphoid to the semilunar bones, and from the semilunar to the cuneiform.

The bones of the second row are united by similar bands to the foregoing, situated on the dorsal and the palmar surfaces. These pass between the os magnum and its associated bones, the trapezoid bands being especially powerful. The pisiform bone is remarkable among its fellows in being isolated from the synovial membrane of the rest of the carpus. The bone is held to the ulna by the internal lateral ligament, and to the fifth metacarpal bone and the hooked-process of the unciform bone by three stout ligaments.

Viewed as a whole the ligaments of the carpus are stronger where they unite the bones of the rows than where they unite the parts of the intercarpal joint. The ligaments of the ulnar side are stouter than are those of the radial.

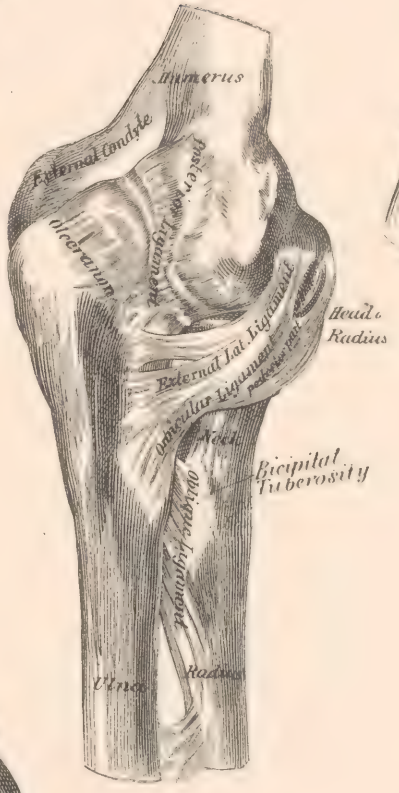
The joint between the two carpal rows is convex on its proximal surface, where for the radial third it is composed of the distal surface of the scaphoid bone, and concave for the ulnar two-thirds through the lateral surface of the scaphoid bone, and the distal surfaces of the semilunar and the cuneiform bones. The distal surface is concave at the lateral (radial) third, where it is made up by the proximal facets of the trapezium and the trapezoid bone; it is convex at the median (ulnar) two-thirds where the distal surfaces of the os magnum and the unciform bones unite to form it. The last-named portion presents well-defined lateral facets.

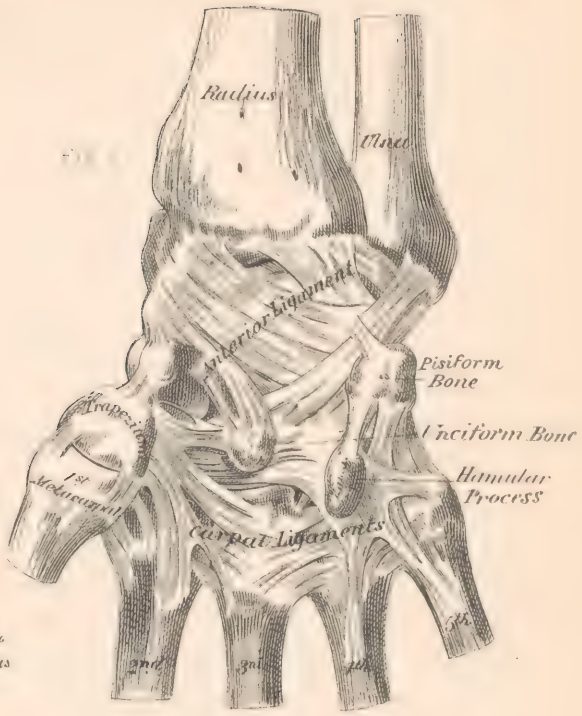
The two rows are united on the palmar surface by an external lateral ligament extending between the scaphoid and the trapezium, as well as by a second

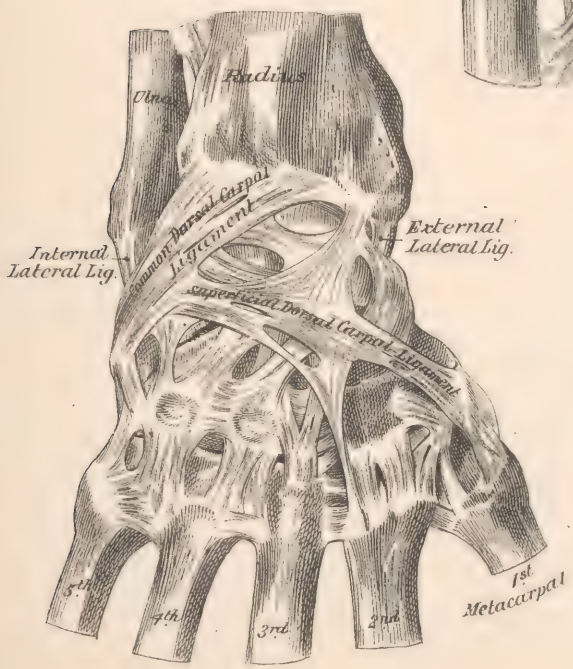
EXPLANATION OF PLATE XXXIX.

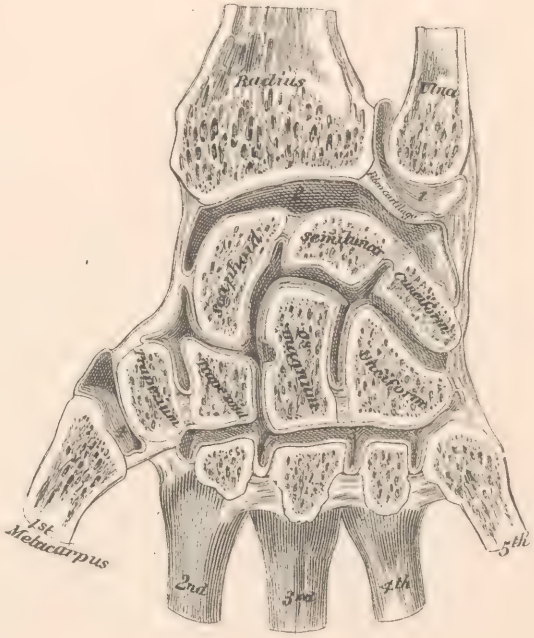
Fig. 1. The elbow-joint, seen from in front.
Fig. 2. The wrist-joint, seen from in front.
Fig. 3. The elbow-joint, seen from the median side.
Fig. 4. The wrist-joint, seen from behind.
Fig. 5. The carpal and metacarpo-phalangeal synovial sacs.











T. Sinclair & Son, Lith.

ligament extending obliquely downward and inward from the scaphoid bone to the os magnum. On the dorsal surface two oblique ligaments pass between the cuneiform bone to the unciform; one from the semilunar bone to the os magnum; another from the scaphoid bone to the os magnum (this acts as an interosseous ligament, separating the lateral from the median portion of the joint); and yet another from the scaphoid bone to the trapezoid bone.

The Synovial Membrane of the intercarpal articulation sends processes upward between the bones of the first row and downward between those of the second, and communicates with the sac between the second row and the metacarpal bones.

The median border of the carpus is strengthened by the external lateral ligament of the wrist-joint.

Movements.—The joint between the two rows is freely movable in flexion and extension. The high degree of specialization noted in the formation of the thumb and index finger is correlated with the forms of the joints intervening between them and the forearm. The lateral third of the joint is restricted to the movements of the first row of carpal bones upon the trapezium and the trapezoid, these bones being in longitudinal serial union with the thumb and the index finger.—The largest surface of contact between the two rows occurs when the second row is strongly extended on the first, as in the act of supporting the body on the hand in creeping.—The median two-thirds of the joint, in addition to flexion and extension, permit a greater degree of locking to occur than in the lateral third.—The lateral facets of the socket-like proximal surface act as supporting or check facets at the limits of pronation and supination.—The interosseous ligament between the scaphoid bone and the os magnum acts as a check to pronation.—The carpus when at rest presents the second row of bones moderately extended upon the first. This is the position instinctively taken after injury of the wrist or body of the hand, and is the one to which surgical appliances should be adapted.

The Nerves of the Carpus. The dorsum is supplied by a branch of the radial nerve; the ulnar aspect, by the interosseous nerve and a recurrent branch of the ulnar nerve; the radial side by a deep branch of the ulnar. The metacarpo-phalangeal and the inter-phalangeal joints are supplied by the ulnar nerve.

The Arteries are derived from the anterior and the posterior branches of the radial and the ulnar, as well as from the interosseous artery and the deep palmar arch.

THE CARPO-METACARPAL AND THE INTER-METACARPAL JOINTS AND LIGAMENTS.

These lines of union are conveniently considered together. Two distinct joints are formed between the surfaces embraced in the title,—one between the first metacarpal bone of the thumb and the trapezium, and one between the remaining metacarpal bones and the trapezoid bone, the os magnum, and the unciform bone.—The first-named joint is saddle-shaped, provided with a loose but stout capsule, strengthened by two lateral ligaments. The outer of these arises from the proximal end of the second metacarpal bone.—The second-named joint is nearly flat or sinuate between the os magnum, the unciform, and the third, the fourth, and the fifth metacarpal bones, but more irregular and angulated between the trapezoid bone, the trapezium, and the second metacarpal bone. The joint is usually strengthened above by two ligaments to each metacarpal bone and below by numerous bands.

The fifth metacarpal bone is united to the unciform by capsule-like bands, recalling the peculiarities of the joint between the first metacarpal bone and the trapezium.—Interosseous ligaments unite the os magnum and the unciform bone with the third and the fourth metacarpal.—An intermetacarpal ligament passes between the third and the fourth metacarpal bones.—A special palmar ligament extends distally and medianly, to unite the trapezium with the third metacarpal bone.

Movements.—The joint between the first metacarpal bone and the trapezium, like saddle-joints elsewhere, permits of free motion in all directions.—The joint between the remaining metacarpal bones and the trapezoid, the os magnum and the unciform bone, is more fixed, but is quite mobile at the fourth and fifth metacarpal bones as compared with that at the second and third.—The capsule-like ligament at the fifth metacarpal bone enables a greater degree of motion to be here displayed than at any other portion of the carpo-metacarpal line.—The least degree of motion takes place at the second metacarpal bone.—The interosseous ligaments act as checks to extremes of movement of flexion and extension.—The fourth and the fifth metacarpals move together upon the nearly fixed third bone.

THE METACARPO-PHALANGEAL JOINT.

The distal extremity of each metacarpal bone presents a large convex surface that is wider below than above, and is joined to a small concave surface on the proximal end of the first phalanx.

The surfaces are united by a capsular ligament which presents the following subdivisions:—

The Anterior Ligament.
The Posterior Ligament.
The two Lateral Ligaments.
The Transverse Ligaments.

The Anterior Ligament (glenoid ligament) is a thickened pad that forms on the palmar surface a firm concavity, in which lie the flexor tendons of the fingers. The sheath of the tendons is closely incorporated with the pad. Its posterior surface is also concave, to receive the palmar aspect of the head of the metacarpal bone.

The Posterior Ligament is weak, bursa-like, and is protected by the tendon of the common extensor.

The Lateral Ligament extends obliquely from the posterior tubercle of the lower end of the metacarpal bone to the anterior tubercle of the proximal end of the first phalanx. It is a powerful ligament, the external being the stronger, though less strong than is the same structure between the phalanges. It is stretched by flexion, and relaxed by extension.

The plan of the metacarpo-phalangeal joint of the thumb recalls that of an inter-phalangeal joint in presenting a small anterior pad, in possessing lateral ligaments, and in retaining the phalangeal character of both articular facets.

The Transverse Ligaments, four in number, unite by loose broad bands the heads of the four median metacarpal bones. They can be felt in the undissected hand beneath the skin of the interdigital spaces.

According to Holden, a furrow of the palm, running transversely across the lower third, "corresponds pretty nearly with the metacarpal joints of the fingers, with the upper limit of the synovial sheaths of the fingers (that of the little finger excepted); also with the splitting of the palmar fascia into its four slips." The transverse metacarpal ligament lies in the same line with the joint. A little below the skin-furrow the digital arteries bifurcate to run along the sides of the fingers.

THE INTER-PHALANGEAL JOINTS AND LIGAMENTS.

The plan of these joints is so similar to the foregoing as not to need a detailed description. The distal surface of each joint is depressed toward the sides and raised in the middle, while the proximal surface is raised at the sides and depressed in the middle. This peculiarity is least marked in the joint between the second and the third phalanges. Exceedingly stout lateral ligaments strengthen each joint that is otherwise unprotected save on the palmar surface where a fibro-cartilaginous pad is seen. Over this structure the tendons of the flexor muscles play.

Movements.—Flexion and extension are here alone possible. A slight degree of rotation is secured by manipulation.

Prof. Cleland[1] has described stout ligamentous structures extending from the sides of the phalanges, to be inserted into the skin. He assumes that such bands aid in retaining the different parts of the integument in the positions which they are adapted to occupy.

The inter-phalangeal joints correspond to the "knuckles." The line of each joint lies immediately in advance of the main prominence of the "knuckle" in flexion, and of the transverse concave skin-grooves in extension.

THE JOINTS AND LIGAMENTS OF THE LOWER EXTREMITY.

The Joints and Ligaments of the lower extremity embrace the following:—

Those of the Pelvis.
Those of the Hip.
Those of the Knee.
Those of the Leg.
Those of the Ankle.
Those of the Foot.

The Joints and Ligaments of the Pelvis.

The bones of the pelvis are held together by four joints and their respective ligaments.

The joints are as follows:—

The Ilio-Sacral
The Symphysis Pubis.
The Sacro-Coccygeal.

THE ILIO-SACRAL JOINT.

The two Ilio Sacral Joints are of the nature of symphysis, and in each instance are formed by the apposition of the auricular facet of the innominate bone against the lateral surface of the sacrum, a thin disk of fibro-cartilage intervening. This disk is friable, and frequently possesses a small cavity containing a glairy fluid.

The ligaments of the ilio-sacral joint are—

The Ilio-Lumbar.
The Anterior Ilio-Sacral.
The Posterior Ilio-Sacral.

[1] Journ. of Anat. and Phys., 1878, 526.

The Ilio-Lumbar Ligament (figs. 1 and 2, Plate XXXIX.) is a stout rounded cord extending from the tip of the transverse process of the last lumbar vertebra to the crest of the ilium.

The Anterior and the Posterior Ilio-Sacral Ligaments are thin layers of fibrous tissue extending from the sacrum to the ilium. Some of these bundles are transverse, others are oblique. The latter are arranged in two fasciculi, the upper extending from the posterior superior spinous process of the ilium to the sacrum; the lower extending from the posterior inferior spinous process of the ilium to the sacrum. Of the two ligaments the posterior is the stronger.

The sacro-iliac junction is easily destroyed by crushing violence. It is thus often involved in fractures of the pelvic bones, when its surfaces have been known to be separated to the distance of two fingers' breadths. Destructive inflammation with suppuration is asserted by Sayre[1] to be a common disease of this articulation, and is invariably of traumatic origin.

Accessory to the ilio-sacral joint are the following ligaments:—

The Greater Sacro-Sciatic.
The Lesser Sacro-Sciatic.

The Greater Sacro-Sciatic Ligament is a broad membrane-like structure extending from the outer portion of the tuberosity of the ischium to the upper posterior portion of the ilium, and the posterior lateral surface of the sacrum. It is slightly contracted in the middle, but expanded toward either end. Its fibres are pierced here and there by minute bloodvessels, and are more or less continuous below with the origin of the Semi-Membranosus muscle and the long head of the Biceps Flexor muscle, and above with the iliac fibres of origin of the Gluteus Maximus muscle.

The ligament converts the great sciatic notch into a foramen, and gives origin to some fibres of the Gluteus Maximus.

The inner surface of the ligament at its ischiatic attachment is continuous through the so-called *falciform process* with the obturator fascia covering the internal obturator fascia, and in like manner with lower fibres entering into the sub-pubic ligament.

The great sacro-sciatic ligament should be associated with the deep fasciæ rather than with true ligaments. It is made tense by action of the Biceps Flexor muscle, and may be considered mainly in the light of an aponeurosis.

[1] Orthopedic Surgery, etc., 327.

The Lesser Sacro-Sciatic Ligament extends between the posterior surface of the spine of the ischium and the sacrum, where some of its fibres are continuous with the Ischio-Coccygeal muscle. It converts the lesser sciatic notch into a foramen.

The greater and the lesser sciatic foramina transmit the following structures: the greater, the Pyriformis muscle, the sciatic and the pudic nerve; the lesser, the Internal Obturator muscle, and the internal pudic nerves and bloodvessels.

The Obturator Membrane.—In addition to the above structures the innominate bones exhibit a firm membrane, occupying the foramen of the same name, which has received the name of the Obturator Membrane. It is pierced near its lower border by the obturator vessels and nerves, and yields surfaces of origin for the Internal and the External Obturator muscles.

THE SYMPHYSIS PUBIS.

The Symphysis Pubis (figs. 3 and 4, Plate XXXIX.) is a joint belonging to the order of symphysis, as the name expresses. Like all the members of this group it possesses an inter-articular disk of fibro-cartilage. Owing to the somewhat bevelled appearance of the median articular surfaces of the pubic bones, a V or Y shaped interval results as they approach one another. The fibro-cartilage of necessity takes the shape of this interval, and is further peculiar in being composed chiefly of cartilage in the basal portion of the V or Y, and of fibro cartilage in the expanded portion. Moreover, the lateral portions of the disk are in intimate union with the tit-like eminences on the pubic surfaces, and retain this connection even after maceration. Not only is the yielding centre of the disk the least fixed of the parts, but it is occupied by a synovial sac. This, in the young of both sexes, and in the male adult, is placed at the basal part of the V or in the stem of the Y, and extends thence forward barely to the centre of the joint. It averages in the adult male a size not greater than that of a split pea. The sac is larger in adult females, and in the parturient may involve the entire thickness of the joint. A moderate degree of motion is possible between the innominate bones during pregnancy and parturition.[1] The position of the symphysis can be felt from within the vagina.

The symphysis is strengthened by accessory fibres

[1] See in this connection J. M. Duncan, Edin. Med. Journ., 1855.

both in front and behind. Those in front are called the Anterior Pubic Ligaments; and those behind the Posterior Pubic Ligaments, and are unimportant. A slender band passing over the tops of the pubic bones has received the name of the Superior Pubic Ligament. A more important arrangement of fibres than the above, is the Sub-Pubic Ligament. It occupies the upper narrowed portion of the sub-pubic arch, and is composed of an intricate interlacement of fibres, which results in the formation of a stout membrane. It is attached above to the under surface of the symphysis, but below is free.

THE SACRO-COCCYGEAL JOINT.

The Sacro-Coccygeal Joint is of the same nature as the intervertebral disks, and does not demand a separate description. The joint is supported by anterior and posterior bands that have received the names of the Anterior and the Posterior Sacro-Coccygeal Ligaments.

The Hip-Joint.

The hip-joint (fig. 1, Plate XLI.) serves to hold the innominate bone and the femur together. It belongs to the enarthrodia, and consists of the acetabulum, the head of the femur, and associated ligaments.

The cartilage lining the acetabulum is thicker at the margins than at the centre, while the cartilage covering the head of the femur is thicker at the centre than at the sides. These surfaces are thus mutually adapted.

The following ligaments are described in connection with the hip-joint:—

The Cotyloid.
The Transverse.
The Capsular.
The Ligamentum Teres.
The Synovial Membrane.

The Cotyloid Ligament is a prismoid elevation of fibro-cartilage whose base corresponds to the osseous lips of the acetabulum. It assists in deepening the socket, while slightly narrowing it at the rim. It is thinner at the anterior and at the posterior borders than elsewhere, and is composed of freely interlacing fibres that ascend obliquely from the bone.

The Transverse Ligament is a simple band of fibro-cartilage extending between the opposite borders of the cotyloid notch. It converts the notch into a foramen, through which bloodvessels and nerves pass into the joint.

The Capsular Ligament is attached above to the innominate bone, and to the transverse and the cotyloid ligaments. Below it terminates at the spiral line of

Fig. 76.



The hip-joint seen from in front. It is dissected to display the ilio-femoral fascicle.

the femur anteriorly, to the lower third of the neck posteriorly, as well as to the bone at points intermediate between these. The capsule is much thicker at the upper, the outer, and the anterior portions than at the inferior and the inner, where it is thin and weak. The fibres are arranged in oblique, longitudinal, and circular bundles. Of these the longitudinal are the

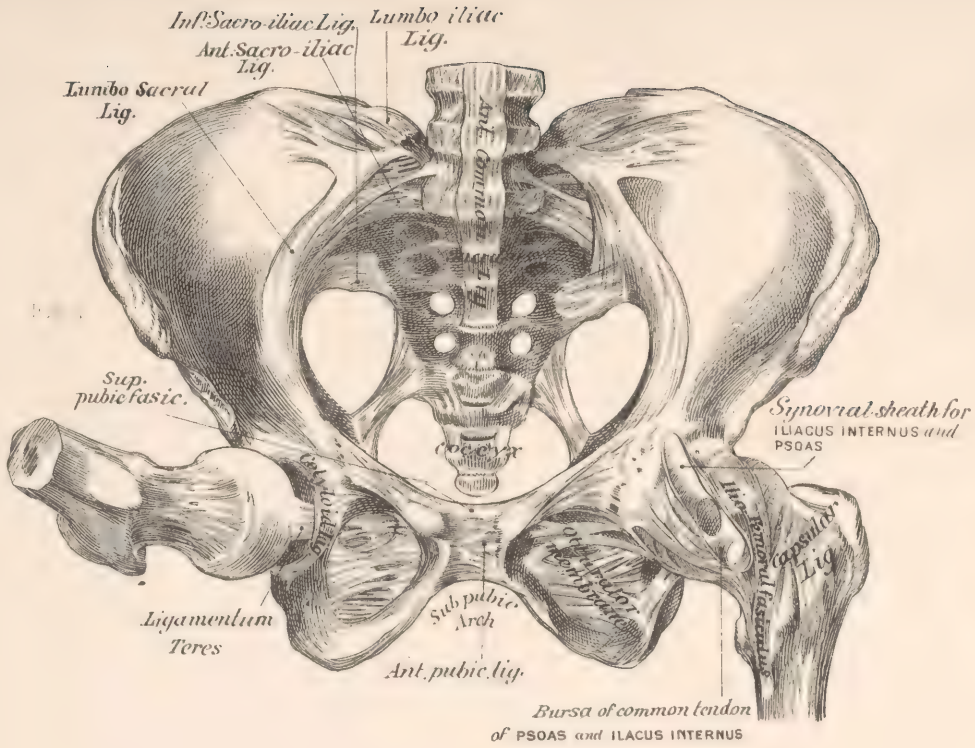
EXPLANATION OF PLATE XL.

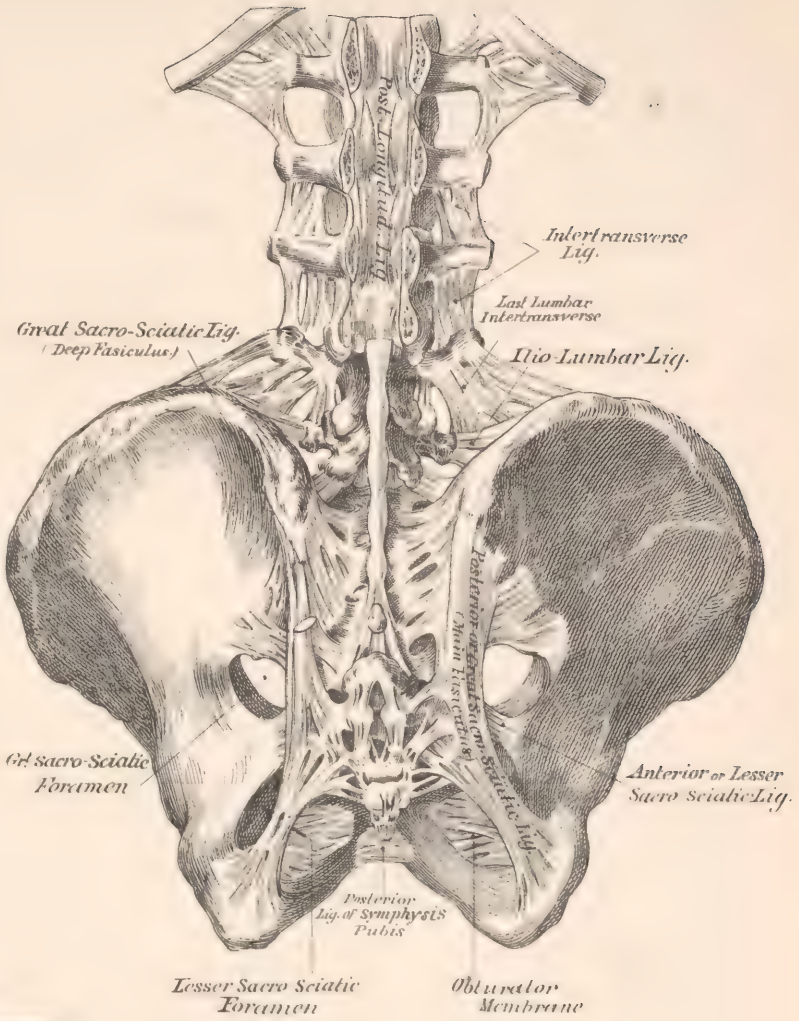
Fig. 1. The ligaments of the pelvis and of the hip-joint, seen from in front.

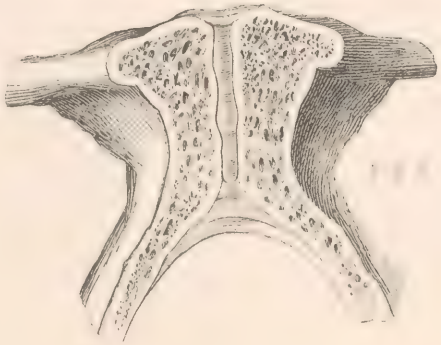
Fig. 2. The ligaments of the pelvis, seen from behind.

Fig. 3. A frontal section of the symphysis pubis.

Fig. 4. A horizontal section of the symphysis pubis.


Inf.r Sacro-iliac Lig.
Lumbo iliac Lig.
Ant. Sacro-iliac Lig.
Lumbo Sacral Lig.
Sup. pubic fasic.
Synovial sheath for ILIACUS INTERNUS and PSOAS
Ligamentum Teres
Sub pubic Arch
Ant. pubic lig.
Bursa of common tendon of PSOAS and ILIACUS INTERNUS


Inter transverse Lig.
Last Lumbar Intertransverse
Great Sacro-Sciatic Lig. (Deep Fasiculus)
Ilio Lumbar Lig.
Gr.t Sacro-Sciatic Foramen
Anterior or Lesser Sacro Sciatic Lig.
Posterior Lig. of Symphysis Pubis
Lesser Sacro Sciatic Foramen
Obturator Membrane



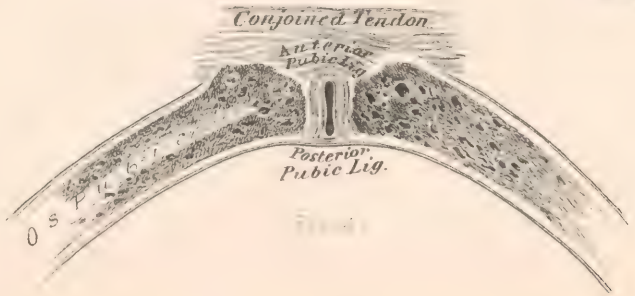

Conjoined Tendon
Anterior Pubic Lig.
Posterior Pubic Lig.

PLATE XI

most important, and extend for the most part along the front of the joint.

A superficial fascicle of great strength (ilio-femoral or Y-shaped ligament), triangular in form, with its base directed downward, is attached above to the anterior inferior spinous process of the ilium, to the space between it and the rim of the acetabulum. It passes downward and outward, and finally bifurcates at the neck of the femur, one bundle going to the spiral line, the other to the depression in front of the lesser trochanter. (See Fig. 76.) In the interval between these branches the deep layer of fibres of the capsule is seen. The anterior surface of the capsule is in close relation with the Gluteus Minimus muscle, and less intimately with the reflected tendon of the Rectus Femoris, and the conjoined tendon of the Iliacus Internus and Psoas Magnus. Between the ligament and the last-named muscles a bursa is seen, which often communicates with the interior of the joint.

The ischio-capsular (ischio-femoral) bundle is attached above to the ischial rim of the acetabulum and the smooth surface between it and the great sciatic notch. The fibres pass horizontally outward, and are lost in the capsule.—A small accessory fascicle, the so-called pubo-capsular ligament (pectineo-femoral) is attached beneath the Pectineus muscle from the pubic border of the obturator foramen or the cotyloid notch, and extends thence to the capsule.—A process of the iliac fascia is detached opposite the pectineal eminence, and passes between the Iliacus Internus and the Pectineus muscle to the capsule.—At points between the above-mentioned fascicles the capsule is weak, and composed of circular and oblique fibres. Of these the circular are the most important. They are especially well developed behind, where they embrace the neck of the femur, and run parallel to the fibres of the Internal Oblique muscle, forming a collar-like band about its lower third, but without attachment to the bone. The synovial membrane is reflected from the femur to the capsule at this point.

The Ligamentum Teres is not round, as the name would imply, but flat. It arises from the edges of the cotyloid notch by two distinct fascicles, which are attached to the transverse ligament, and by a third less defined root, which is derived from the border of the depressed base of the acetabulum that supports a cushion of fat. The ligament ascends round the head of the femur, to be attached to a depression a little below the centre. The ligamentum teres is broader and more compact at its upper than at its lower attachment. It tends to check rotation outward in the flexed position.

The Synovial Membrane is in contact with the opposing surfaces, encloses the round ligament, and is supported by the lower and inner parts of the capsule.

Movements.—The movements of the hip-joint consist of extension, flexion, adduction, abduction, and rotation. The terms eversion and inversion, while referring to the limb as a whole, are determined by the hip-joint. *Eversion* of the limb corresponds to extension with rotation outward, *inversion* to extension with rotation inward. Rotation is naturally less exact when the joint is extended than when it is flexed, since in the first-named position the movement is restricted by the tense ilio-femoral fasciculus, while in flexion the relaxed capsule and the tense ligamentum teres—in the event of flexion being combined with rotation outward—alone restrict it. Extremes of rotation upward are checked by tension of the lower part of the capsule as well as by the contact of the lower border of the neck against the upper margin of the acetabulum.—Extreme of rotation downward brings the most convex portion of the head against the shallowest part of the socket. The movement is checked by the ilio-femoral fasciculus.

Dislocations of the hip will be determined by the ineffective resistance presented in the checks to the various movements of the joint. It will require a greater force to effect dislocation in extension than in flexion, and in flexion with adduction than in flexion with abduction.

In addition to the above elementary statement of the hip-joint movements, the following more elaborate description is herewith presented.

Extension is effected by the head of the femur being thrown forward, and one-half of its anterior surface, viz., that answering to the anterior aspect of the neck, brought out of the acetabulum, while a small portion of the under and posterior surface lies within that cavity. In extension the ilio-femoral fasciculus is tense.

Flexion is the reverse of the above-named movement. The anterior aspect of the head and a small portion of the neck now recede within the acetabulum, while the upper and posterior parts are brought out. In flexion the ischio-femoral fasciculus is tense, and the ilio-femoral relaxed. In flexion combined with adduction the lower portion of the head passes well within the acetabulum, but is free near the neck else-

where. The ligamentum teres is tense. In flexion combined with abduction the head passes entirely within the socket superiorly, but inferiorly is brought out, and is supported by the lower and the inner part of the capsule, which is now tense, while the ligamentum teres is relaxed.

It follows, from what has been seen of the relative degrees of strength of the parts of the capsule, that the joint is best protected in the position of extension, and least so in the position of flexion with abduction.

Rotation is defined in two ways,—rotation with extension, and rotation with flexion. The first-named is necessarily limited, since it takes place while the powerful ilio-femoral ligament is tense. In the living subject it is best measured by the arc of movement of the great trochanter. Rotation with flexion is free in all directions save that of flexion with adduction, which is checked by the tension of the ligamentum teres.

The extreme of upward movement is checked by tension of the lower part of the capsule as well as by contact of the lower border of the neck against the upper border of the acetabulum. The extreme of downward movement is checked by the forced contact of the head against the most convex portion of the tense ilio-femoral fasciculus.

Rupture of the ilio-femoral fasciculus would cause dislocation on extension of the joint, as in the act of standing erect. A wrench of the femur downward and backward while the thigh is raised, and the joint flexed, would cause dislocation, since in this position the weight is thrown against the weak posterior and under part of the capsule. The liability to luxation is increased if the joint is adducted.

An exact knowledge of the actions of the ilio-femoral fasciculus in retaining the head of the femur in its false positions during dislocation has been shown by Dr. H. J. Bigelow[1] to be of great importance. This observer has found the external branch of the fasciculus in dorsal dislocation to hold the limb in an inverted position. Should eversion exist with this dislocation, the external branch of the ligament is ruptured. In anterior oblique dislocation the head of the femur is hooked over the ligament, which is entire. In supra-spinous dislocation the head, as in the preceding example, is hooked over the ligament, but the external branch is ruptured. In pubic dislocation the range of the femur upon the pubes is limited by the ligament, which in the sub-spinous dislocation also binds the neck of the femur to the pelvis. In the thyroid dislocation the limb is everted by the agency of the ligament, and the trochanter rests upon the pelvis. In dislocations which are the result of extreme force the ilio femoral fasciculus is ruptured.

Congenital dislocation of the hip, by altering the lines of pressure of the trunk upon the inferior extremity, induces pronounced anterior inclination of the pelvis, a condition which acts indirectly as a cause of antero-posterior curvature of the lumbar vertebræ.

The cervical portion of the capsular ligament is subject to many variations. It has been found by Dr. G. K. Smith[1] that the ligament may be attached to the neck nearer the head in some subjects than in others.

The hip-joint receives Nerves on the posterior surface from the ischiatic nerve as it supplies the Gemellii and the Quadratus Femoris muscles, and on the anterior surface from a branch of the obturator nerve.

The Arteries giving branches to the hip-joint are the internal circumflex, the gluteal, the obturator, and the sciatic.

The Hip.

The Knee-Joint.

The knee (figs. 2, 3, 4, Plate XLI.) is the largest and most complicated joint in the body. It is composed of the femoral condyles, the tibial condyloid surfaces, and the patella, together with a pair of inter-articular disks, the whole being bound together with appropriate ligaments.

The joint thus presents for examination—

The Capsular Ligament.
The External Lateral Ligament.
The Internal Lateral Ligament.
The Inter-Articular Cartilages.
The Transverse Ligament.
The Crucial Ligaments.
The Synovial Membrane.

The Capsular Ligament is united to the margin of the glenoid cavities of the tibia below, and the tuberosities and lower portion of the popliteal surface of the femur above. It is in addition attached to the margin of the patella and to the patellar ligament in front, as well as to the outer broad surfaces of the semilunar cartilages at the sides. It is of unequal strength and thickness, being strong behind, but weak in the neighborhood of the patella. It is incorporated behind with the tendon of the Semimembranosus muscle, at the side with the lateral ligaments, at the front

[1] The Insertion of the Capsular Ligament of the Hip-Joint and its Relation to Intra-Capsular Fracture. Pamphlet. New York, 1862.

and the inner side with an aponeurotic expansion from the Vastus Internus and the Sartorius muscles, and at the front and the outer side with an expansion from the fascia lata.

The capsular ligament is strengthened by the *ligamentum patellæ*—a structure representing the tendon of the Quadriceps Extensor muscle as it lies between the patella above and the tubercle of the tibia below. It is slightly broader at its upper than at its lower attachment, and is continuous at its outer margin with the capsule. Between the ligament and the skin is lodged a quantity of fat, while between the ligament and the tibia lies an important bursa. Behind, the thick, flat, and unyielding capsule (here often called the Ligamentum Winslowi) is composed for the most part of vertical fibres, which are to some degree in association with the tendons of the Gastrocnemius, the Popliteus, and the Plantaris muscles. A well-defined superficial oblique bundle (oblique fasciculus), which serves as a reflection of the tendon of the Semimembranosus muscle, is directed upward and outward.

Under the name of the *ligamentum arcuatum* is described a fascicle which is attached above at the outer femoral condyle, and below to the inter-condyloid fossa beneath the oblique bundle. The deepest portion of this accession answers to the capsule, as it covers the bursa lying beneath the tendon of the Popliteus muscle. At its lower border the fascicle receives some of the fibres of the Popliteus muscle, as well as a few ligamentous bands attached below to the head of the fibula between the insertion of the Biceps and the origin of the Soleus muscle.

Notwithstanding its great strength the posterior portion of the capsule will yield to pressure from an abscess or aneurism. In this manner pus or blood may reach the interior of the joint from the ham. Of the former lesion J. Adams[1] reports an example. In the course of the treatment of an abscess which had been opened through the skin this writer observed that the pus ceased flowing at a time coincident with swelling of the joint. A free incision being made, a quantity of pus escaped from the interior of the joint, and an opening was discovered in the posterior capsular fibres, by means of which the abscess in the ham had communicated with the joint. Both the Ligamentum Winslowi and the popliteal artery have been ruptured by the fall of a sack of wheat on the thigh.

The External Lateral Ligaments are two in number—the long and the short ligament. The *long ligament* is a stout rounded cord extending from a small prominence situated above the sulcus, near the Popliteus muscle, and in front of the point of origin of the outer head of the Gastrocnemius. It passes downward on the line of the fibula, and is attached to the outer part of the head of that bone. A bursa is often seen between it and the tendon of the Biceps. The ligament closely resembles the last-named tendon, and passing as it does along its anterior border may be confounded therewith. Inferiorly it becomes united with the tendon, and sends an expansion to the patella.

The *short external lateral ligament* is a fasciculus, variable in size, attached above to the outer femoral tuberosity, and passing downward and outward to the styloid process of the fibula. It is often connected with the tendon of the Popliteus muscle, and may end either on the capsular ligament or the tibial aponeurosis.

The Internal Lateral Ligament is a broad membranous expansion passing from the inner femoral condyle from a point below the tubercle for the attachment of the Adductor Magnus muscle, downward and outward to be attached to the corresponding tuberosity and the anterior surface of the shaft of the tibia. Superficially the ligament, as it lies on the tibia, is in relation with the aponeurotic structures of the tendons of the Sartorius, the Gracilis, from which it is separated by a bursa, and the Semitendinosus muscles, and, on a deeper plane, with the aponeurosis of the Vastus Internus muscle. Beneath lies a considerable portion of the Semimembranosus muscle. The deeper fibres of the ligament are attached to the posterior part of the corresponding interarticular cartilage, and is in contact with the synovial membrane. The ligament is further attached to the aponeurosis covering the Popliteus muscle, and to the oblique fibres of the ligament of Winslow.

Rupture of the internal lateral ligament with displacement of the semilunar cartilages is instanced in the following case recorded by Adams.[1] A man aged thirty-two while in the sitting position received a blow upon the inner part of the knee. Forced abduction followed with undue mobility. An abnormal interval measuring three-fourths of an inch in width existed between the extremity of the femur and the head of the tibia. Recovery was secured with a good limb.

The Interarticular Cartilages (semilunar cartilages

[1] Lancet, 1859, 155.

[1] Med. Times and Gaz., 1857, 603.

or disks) are two in number, and are named from their position the *internal* and the *external* cartilage. They are wide and thick without, but thin and compressed within, and apparently belong to the tibia to the plane of whose articular surfaces they correspond. The lower surfaces are flat, while the upper are concave for the reception of the femoral condyles. Each cartilage covers one-third of the tibial articular surface, to the border of which it is fixed by short fibrous bands, which collectively receive the name of the *coronary ligament.* The *internal cartilage* is of a semilunar figure, narrow and pointed in front, and to a moderate degree fixed to the anterior border of the anterior tibial concavity. It passes backward to be attached to the inner side of the intercondyloid notch. The ends of the cartilage are separated by the entire breadth of the tibial surface. The internal cartilage is in marked contrast to the external, since it sends off no fibres to the crucial ligament. The *external cartilage* is more circular in form than the internal, and is grooved upon its outer side by the tendon of the Popliteus muscle. It is attached in front to the depression in advance of the spine of the tibia, and behind, for the most part, to the space between the two tubercles of the spine of the tibia. The anterior and the posterior ends of this cartilage are of the same size, and are so near each other as to lie within the curve of the internal cartilage, which thus corresponds to the arc of a larger circle than the one described by the external. Small bundles of fibres pass from the external cartilage to the crucial ligament.

The Transverse Ligament is a narrow band of fibres stretching across between the anterior extremities of the interarticular cartilages.

The Crucial Ligaments, or crossing ligaments, are broad though short bands, two in number, and named from their position the anterior and the posterior, extending from the space before and behind the spine of the tibia to the posterior condyloid notch of the femur. The two in crossing describe a figure resembling the letter X, and form a kind of partition between the right and the left sides of the joint. Both ligaments are connected with the external interarticular cartilage.

The *anterior crucial ligament* is attached anteriorly to the inner side of the depression in front of the spine of the tibia. It lies in front of the external interarticular disk, with which it is in part blended. It increases in breadth as it passes upward and outward, and is attached above to the inner and hinder part of the inner surface of the external condyle. The *posterior crucial ligament* is broader and stouter than the anterior, and is attached below to the depression behind the spine of the tibia. Gaining a slight accession from the external interarticular cartilage, it passes upward and a little outward to be attached to the posterior condyloid femoral notch (which it for the most part occupies) as well as by a few fibres to the outer side of the inner condyle.

The crucial ligaments may be ruptured by violence. Mr. Poland[1] records a case of a man forty years of age who incurred an injury of the right knee by a sack of wheat falling upon the thigh of the corresponding side. Amputation was found to be necessary, owing to rupture of the popliteal artery. Examination of the knee demonstrated rupture of the anterior crucial ligament.

The Synovial Membrane is more extended than any other in the body. In addition to lining the capsular ligament, and covering the articular surfaces of the bones entering into the joint, it is reflected from the fat lying between the ligamentum patellæ and the space in front of the head of the tibia; surrounds the crucial ligaments and the tendon of the Popliteus muscle; is reflected upon the interarticular cartilages, and is in contact with the internal lateral ligament at the inner condyle of the femur. The membrane conforms, as a rule, to the shape of the capsular ligament, but above it extends as a *cul-de-sac* beneath the tendon of the Quadriceps Extensor muscle to the distance of several inches. Below to its outer side (and guarded by the tendon of the Popliteus muscle) it sends a prolongation backward and outward upon

[1] Med. Times and Gazette, 1866, 6.

EXPLANATION OF PLATE XLI.

Fig. 1. The hip-joint, seen from in front.

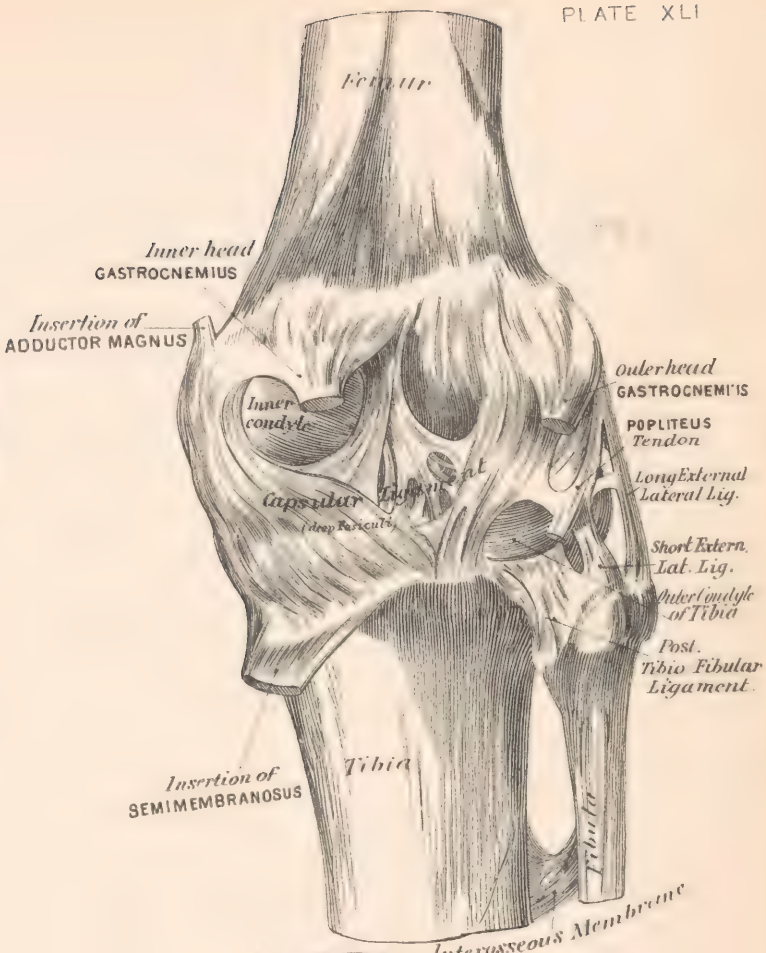
Fig. 2. The knee-joint, seen from behind, showing capsule.

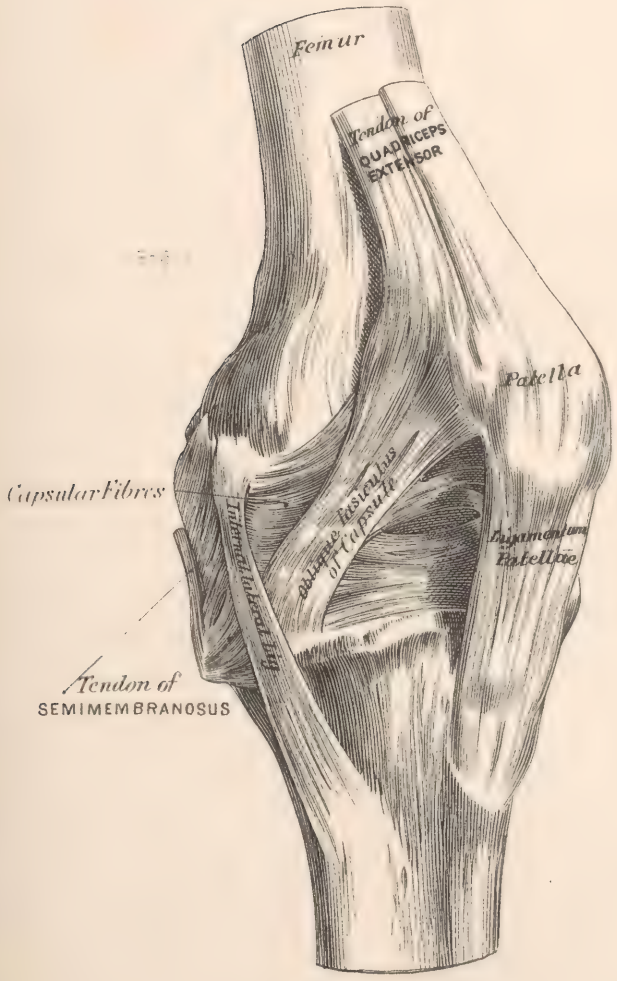
Fig. 3. The knee-joint, seen from the median side

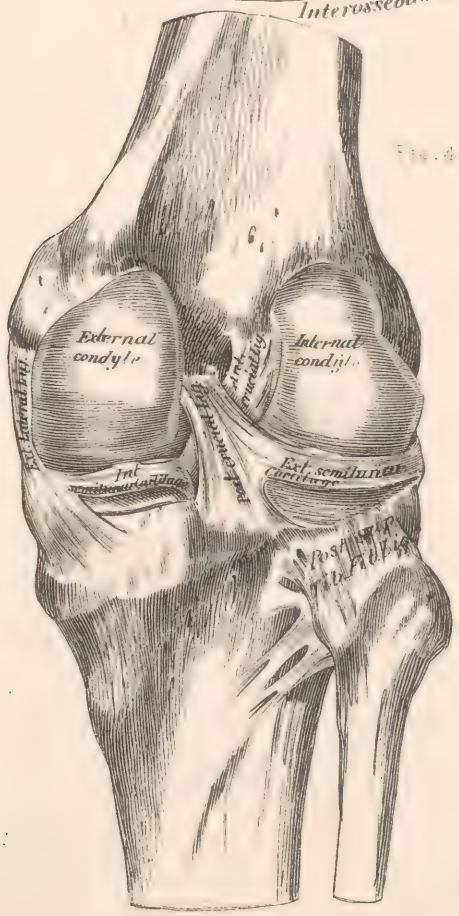
Fig. 4. The knee-joint, seen from behind, showing position of the disks and the crucial ligaments. The names "Internal Condyle" and "External Condyle" should be transposed.

PLATE XLI









T. Sinclair & Son, Lith.

the outer border of the external interarticular cartilage toward the tibio-fibular articulation, with which it communicates, it is estimated, in one out of every six cases. Behind it passes between the femoral condyles and the origins of the Gastrocnemius muscle. Synovial fringes are present at the lower and front part of the joint, and are especially conspicuous about the lateral margins of the patella and the interarticular cartilages to constitute the two *alar ligaments*, so called. These, beginning at the front and at the sides of the joint below, unite in a rounded cord containing a few ligamentous fibres, and are prolonged backward and upward to the front of the upper condyloid notch.

Beneath the synovial membrane at the sides of the patella, and in front of the femur, a quantity of fat is deposited.

When the knee is extended, the top of the *cul-de sac* lies two inches above the upper margin of the patella. In the flexed position it is lower. Inferiorly the synovial membrane lies a little above the level of the upper part of the head of the fibula.

Cysts forming in the ham are liable to be fixed to the inner tendon of the Gastrocnemius (five cases in twenty); when situated in the middle of the ham there may be hernial protrusions of the synovial membrane of the knee-joint through the posterior portion of capsules (six cases in twenty). They are frequently complicated with hydrarthrosis.[1]

The form of the capsule can be often made out in some of the forms of distension with synovial effusion. Thus the swelling is apt to be rounded and uniform at the inner side of the joint, while inconspicuous and irregular on the outer side. The patellar *cul-de-sac* may be measurably separated from the rest of the joint, and the prolongation about the tendon of the Popliteus muscle may be completely separated from the main cavity of the joint.

Movements.—The movements of the knee-joint are both gliding and rolling. The gliding occurs between the external condyle of the femur and the external interarticular disk, and between the posterior half of the internal condyle and the internal articular disk, as well as at the patellar groove between the patella and the outer condyle. The rolling takes place between the interarticular disks and the tibial condyles, especially at the outer half of the joint and between the narrow oblique facet interpolated between the internal condyle and the patellar groove, which has received the name of the *oblique facet of Meyer*.

Without the aid of the interarticular disks none of the above motions can be effected. The disks convert the sinuate or flat tibial surfaces into shallow cavities admirably adapted to serve as sockets for the femoral condyles. The differences in the shapes of the condyles as contrasted with those of the interarticular disks indicate that the lines of action of each of the condyles are distinct. Flexion and extension, which are in this sense equivalent to the action of gliding, are more complete in the outer than in the inner half of the joint. In this connection it is well to remember the less fixed and more rounded form of the outer disk as compared with that of the inner, and the decided manner in which the ligaments check the extremes of motion. The longer external lateral ligament, for example, is a well-defined cord-like band of great strength placed further back than is the internal lateral ligament. It is, therefore, of the two the more thoroughly relaxed, while in extension the same ligament is made proportionally more tense. As the joint is flexed, a disposition exists for the tibia to rotate upon its longitudinal axis. This movement takes place, it is thought, between the external femoral condyle and the external disk acting as one factor, and the outer tibial condyle as the other. Meyer estimates that the degree of rotation here effected is in direct ratio to the angle of flexion of the limb at the knee, when it is seen of necessity to be dependent upon the extent to which the ligaments of the external condyle have become relaxed. Flexion of the outer half of the joint is limited by the anterior crucial ligament which becomes tense in extreme flexion, while extension is limited by the posterior crucial ligament. In moderate degrees of flexion, namely, those that most likely occur in the acts of walking, sitting, etc., the anterior crucial ligament is relaxed.

In flexion of the inner half of the knee the movement is seen to be guarded by the weaker and fascia-like internal lateral ligament which is placed well forward, as also by the broad bands accessory to the capsule at this place. The posterior crucial ligament assists the internal lateral ligament in keeping the inner condyle in position, but the last-named, as has already been seen, is less relaxed in flexion.

The rotatory movement at the inner side of the joint is also much less pronounced than at the outer. On the other hand, the rolling motion between the internal disk and the inner femoral condyle at the oblique facet is increased, and a peculiar curve upward and inward is described, that has been compared to the figure of the spiral, hence the name of screw-motion

[1] Foucher, Archiv. de Médecine, 1856.

that Meyer has given to it. This movement of the knee is seen, it is thought, in the act of raising the leg and bringing it over the thigh of the opposite side. Rotatory movements of the knee are limited by the crucial and the capsular ligaments.

Extremes of flexion and extension are liable to be followed by rupture. The lesions of this class have been formulated by L. Dittel[1] as the result of experiments upon the dead body. This observer, by forcibly flexing the knee in a specimen prepared by removal of the muscles, found that the *anterior* crucial ligament ruptured at its femoral attachment. By placing the knee of a similarly prepared limb over the interval between two blocks, a violent blow with a mallet (thus imitating the force of hyper-extension) caused in some instances rupture of the *posterior* crucial ligament at its femoral attachment.—In another series of experiments a strong man placed the lower extremity of the subject over his shoulder with the posterior surface of the knee upward, and induced hyper-extension of the knee by forcibly dragging the leg downward. This experiment performed upon a young individual separated the tibial epiphysis posteriorly, the ligaments remaining for the most part uninjured; upon old individuals the femoral condyles irregularly fractured the tibial articular surfaces, the ligaments, as before, being preserved intact. If in the latter experiment the leg was carried at a right angle to the femur, both crucial ligaments were found ruptured,—the anterior at its femoral, the posterior at its tibial attachment.—In forced abduction of the extended joint the internal lateral ligament was found ruptured in the middle, or at the tibial or femoral end. In forced adduction similar lesions occurred in the external lateral ligament.

Movement outward is checked by a band of the capsule which has received the name of the *lateral accessory ligament* of Henle, while movement inward is checked by an analogous band on the median side of the joint called the *median accessory ligament* of Henle. Rotations in the extremes of extension and flexion are checked by the crucial ligaments, particularly by the anterior.

The knee, while thus seen to be capable of extreme flexion, does not possess this function so exactly as does the elbow joint, with which of all the joints the knee can be most advantageously compared. In the elbow, for example, the Brachialis Anticus lies upon the flexor aspect, and determines an exact line of bending. No similar muscle is situated upon the flexor surface of the knee. The flexors instead are placed at the sides, and are therefore modified flexors only, since they not only flex, but incline the limb toward the side where the bending forces are the strongest.

The knee is further assisted in maintaining the apposition of its several parts by the fascia lata, especially that portion which lies in direct line with the Tensor Vaginæ Femoris muscle.[1]

Nerves.—The knee-joint receives upon its anterior surface a branch of the long saphenous nerve; upon its external and anterior surface a branch of the peroneal nerve (this twig lies in company with an articular artery); externally and posteriorly by a twig of the anterior tibial nerve; internally (medianly) by a twig from the posterior tibial nerve; externally by a recurrent branch of the deep branch of the peroneal nerve, while the interior of the joint through the posterior crucial ligament receives a branch of the posterior tibial nerve.[2]

The Tibio-fibular Articulations.

The tibia and the fibula are joined (fig. 1, Plate XLII.) by two simple articulations called from their positions the superior and the inferior tibio-fibular joints.

The superior tibio-fibular joint surfaces are oval in form, nearly flat, and obliquely disposed. The tibial surface is the larger, and looks downward and outward. The synovial membrane is rather loose, and occasionally communicates with the sheath of the Popliteus muscle, and thence with the knee-joint. The tendon of the Biceps Femoris muscle is of equal value with the ligaments in maintaining the apposition between the facets of the joint.

The superior ligaments are two in number—

The Superior Anterior Tibio-Fibular Ligament.

The Superior Posterior Tibio-Fibular Ligament.

The Superior Anterior Tibio-Fibular Ligament is attached in front to the external condyle of the tibia, and passes downward and outward to be attached behind to the head of the fibula.

The Superior Posterior Tibio-Fibular Ligament is a single thick, short band extending from the tibia at the lower border of the groove for the tendon of the Popliteus muscle to the head of the fibula. It is covered by the last-named muscle.

[1] Stricker's Med. Jahrbucher, 1876, 319.

[1] For additional literature upon lesions of the ligaments, etc., of the knee, see A. Bruce, Trans. Path. Soc., London, vol. xviii.—Guy's Hosp. Reports, 1867. Lancet, 1859, ii. 240.

[2] H. Meyer, Virchow's Archiv., vol. xii. 124, 1857.

The inferior ligaments are three in number—

The Inferior Anterior Tibio-Fibular Ligament.

The Inferior Posterior Tibio-Fibular Ligament.

The Inferior Interosseous Membrane.

The Inferior Anterior Tibio-Fibular Ligament is of a triangular shape, and is attached to the anterior border of the tibia just above the surface articulating with the astragalus. It passes obliquely downward and outward to the anterior part of the external malleolus. This ligament projects a short distance, viz., about two lines beyond the articular surfaces it serves to unite. It is here covered with cartilage, and is continuous with the ankle-joint. It is sometimes composed of from two to three distinct fasciculi.

The Inferior Posterior Tibio-Fibular Ligament is shorter than the anterior. It passes from the tibia downward and outward to be fixed at the internal border of the groove upon the posterior part of the external malleolus. Both of the inferior ligaments are of great strength, and serve not only to sustain the fibula in apposition to the distal end of the tibia, but to assist the proximal end as well.

The Inferior Interosseous Ligament is triangular in form, with its base directed downward. Its oblique fibres intimately unite the tibia and the fibula between their contiguous surfaces at the lower three-fifths of their shafts. It is continuous above with the interosseous membrane. The small synovial surface is continuous with the ankle-joint.

The tibia and the fibula in addition to the above joints are connected by the interosseous membrane.

The Interosseous Membrane.

The Interosseous Membrane (superior interosseous ligament) (fig. 1, Plate XLII.) passes between the external border of the tibia and the external ridge of the fibula. It is broader above than below, but does not entirely occupy the interosseous space. The deficiency at the upper part of the space permits the passage of the anterior tibial artery, while the one below accommodates the peroneal artery and vein in their passage from behind forward.

Remarks.—The movements of the superior articulation are much freer than those of the inferior. The lateral motion of the fibula against the tibia is greater than the disto-proximal motion. The latter, indeed, is of necessity slight, owing to the overlapping of the tibial condyle at the superior fibular facet, the shortness of the fibres of the inferior group of ligaments, and the strength of the middle external lateral fascicle.

Nerves. The superior tibio-fibular joint receives its nervous supply posteriorly from a twig from the posterior tibial nerve as it supplies the Popliteus muscle, and anteriorly from a recurrent branch from the peroneal nerve.

The Ankle-Joint.

The parts entering into the ankle-joint (fig. 1, 4, Plate XLII.) are the tibia, the fibula, and the astragalus. The union of the tibia and fibula forms a sort of arch or mortise having a greater breadth from side to side than from before backward to receive the proximal surface of the astragalus.

The antero-posterior curve in the last-named surface is greater than that derived from the tibia and the fibula, so that all of the astragalar surface is not in contact with the mortise at one time. The posterior end being about one-sixth smaller than the anterior, it follows that the lateral borders slightly diverge from before backward. In addition to this the sides of the astragalar surface are abrupt. The inner, the shorter of the two, is inclined somewhat outward; the outer is abruptly deflected outward at its lower end; the external malleolus may thus impinge upon the astragalus when the trunk is in the erect position.

The posterior portion of the superior astragalar surface exhibits a distinctive facet for articulation with the surface of the inferior interosseous ligament entering into the joint.

The ankle-joint is composed of—

The Internal Lateral Ligament.

The External Lateral Ligament.

The Synovial Membrane.

The Internal Lateral Ligament (deltoid ligament), the stoutest of the ligaments of the ankle-joint, is a broad, coarsely fasciculated structure attached above to the internal malleolus, and below, by a broad line, to the astragalus, the calcaneum, and the scaphoid bone. It consists of two layers—a superficial and deep. The *superficial* and larger layer is attached above to the apex and the sides of the malleolus, and below to the points already mentioned. The *deep* layer is much shorter than the superficial. It passes downward and backward to connect the deep portion of the internal malleolus with the astragalus.

The superficial layer is divided into two more or less distinct anterior and posterior fasciculi. The *anterior fasciculus* is thinner than the posterior. It is attached above to the anterior border of the internal malleolus, and below to the inferior calcaneo-sca-

phoid ligament and the scaphoid bone. It extends the length of the median border of this ligament.—The *posterior fasciculus*, somewhat rectangular in shape, is attached above to the inferior surface of the superior aspect of the internal malleolus, and below to the astragalus and the calcaneum.

The internal lateral ligament protects the surface of contact with the internal malleolus in all its motions.

The External Lateral Ligament, conventionally so called, is composed of three distinct ligaments, named, from their relative positions, the anterior, the middle, and the posterior fascicles.—The *anterior fascicle*, the shortest of the three, is attached above to the anterior border of the external malleolus; it passes almost horizontally forward and inward to be attached to the astragalus at the junction of the neck and the body. It often splits into two bundles. In flexion it touches the anterior tibio-fibular ligament.—The *middle fascicle*, the longest of the three, is also the strongest. It assumes the form of a rounded cord, which is fixed above to the fibula directly in front of the apex of the external malleolus, and below to the external surface of the calcaneum.—The *posterior fascicle*, the weakest of the three, and more deeply situated than the others, passes nearly horizontally inward from a groove on the inner side of the external malleolus to the posterior surface of the astragalus on the groove between the upper and the lower articular surfaces. In extension of the ankle-joint this ligament touches the lower border of the posterior inferior tibio-fibular ligament.

No capsule, properly speaking, exists at the ankle-joint. The joint is protected in front and behind by dispositions of fibres having little strength. The fibres of the posterior set have the same general arrangement as those of the ligament last named.

The Synovial Membrane is unyielding on the sides where it answers to the malleoli, and where it lies in contact with the ligaments of the ankle and those of the inferior tibio-fibular joint, but is relaxed and loose both in front and behind to such a degree as to permit, during flexion and extension, transverse creases or folds to form. Anteriorly the membrane extends a short distance upon the neck of the astragalus, from which it is separated by a small quantity of fat. This prolongation is divided into a number of imperfectly defined compartments by a series of vertically disposed septa. Superiorly the membrane lies between the tibia and the fibula to constitute the inferior tibio-fibular joint, as already seen. The outer surface of the membrane is in association anteriorly with the tendons of the extensors of the toes, and posteriorly with the tendons of the Gastrocnemius and the Plantaris muscles. The tendon of the last-named muscle may be said to exercise a tensile power over the membrane. The synovial fringes which are so conspicuous in the knee-joint are in the ankle absent or insignificant.

Movements.—The movements of the ankle-joint are in the main those of the ginglymoid joints. When the weight of the body is borne directly upon the astragalus, as in *standing erect*, the astragalus acts as a continuation of the shaft of the tibia, and serves to transmit the weight of the body to the arch of the foot. In this position the ligaments are relaxed, and the bone has a disposition to glide forward, since the upper articular surface is narrower behind than in front. This tendency is checked by the interosseous calcaneo-astragalar ligament, and by the impact of the astragalus against the scaphoid and the ligamentous bands uniting the last-named bones to each other and to the bones of the leg.

In *extension*, the anterior fifth of the superior astragalar surface is exposed, as is the corresponding portion of the articular surface for the external malleolus. The movement is checked laterally by the anterior fascicle of the external lateral ligament, which, while becoming tense, assumes a direction obliquely downward and inward; the middle and posterior fascicles are relaxed. The movement is checked medianly by the anterior half of the deltoid ligament, while the posterior half is relaxed.

In *flexion*, the narrowed posterior third of the

EXPLANATION OF PLATE XLII.

Fig. 1. The ankle-joint, seen from behind.

Fig. 2. The dorso-ventral section of the tarsus, showing synovial sacs. For the word "metacarpus" substitute "metatarsus."

Fig. 3. The proximal end of tibia with the interarticular disks in position, and the tibial attachments of the crucial ligaments displayed.

Fig. 4. The ligaments of the foot, seen from the median side.

Fig. 5. The ligaments of the foot, seen from beneath.



Fig. 1

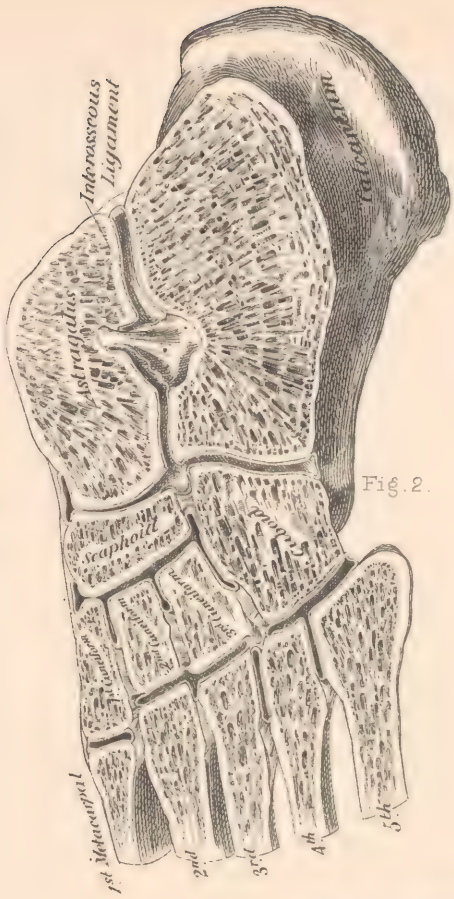


Fig. 2.

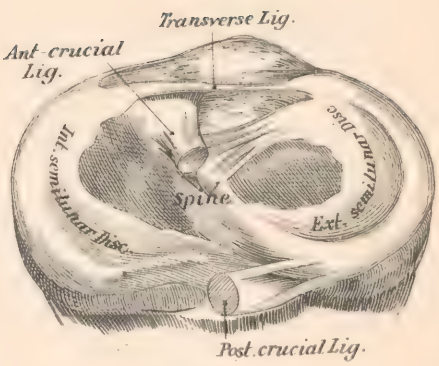


Fig. 3

Fig. 4

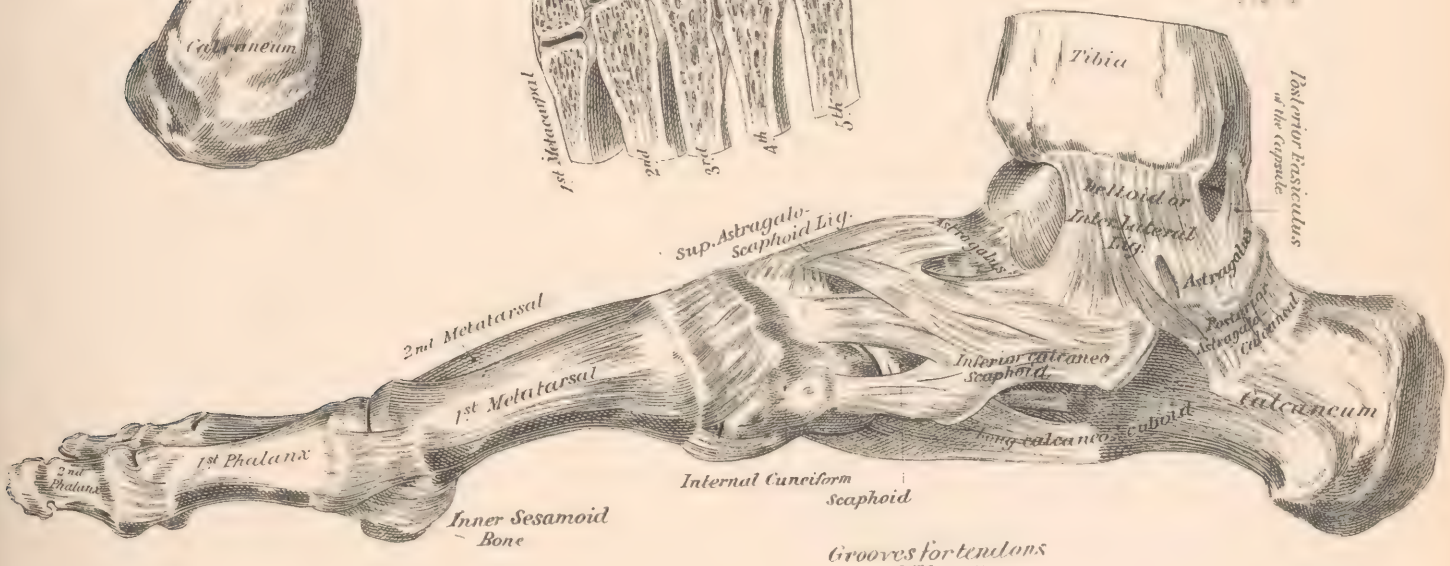
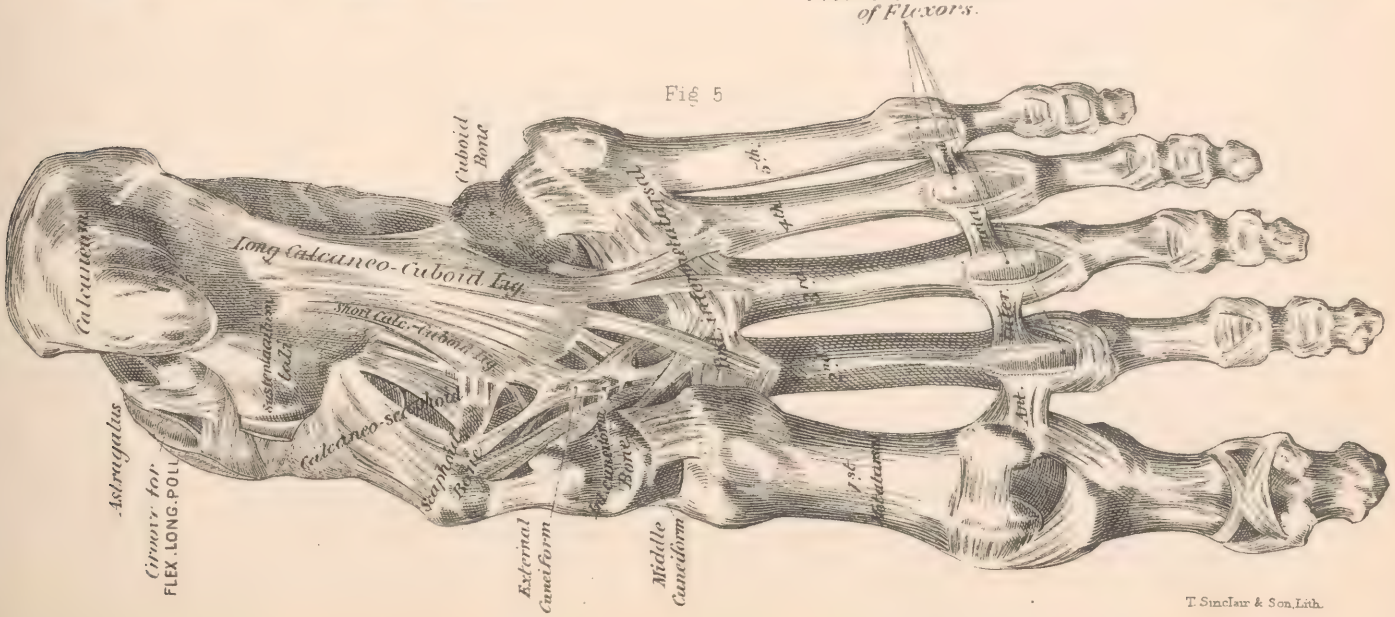


Fig 5



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superior articular surface is exposed, including a small portion of the surface of the outer malleolus, while ligaments relaxed in extension are now tense, and those previously tense are now relaxed. The movement is limited by the anterior lip of the tibial surface impinging against the neck of the astragalus. The ankle-joint in flexion is firmly fixed; rotation of the bones of the leg is transmitted to the astragalus: and motion takes place between the astragalus and the calcaneo-scaphoid concavity. In extension a very slight lateral motion is perceptible between the tibia and the astragalus.

The middle fascicle of the external lateral ligament and the analogous band in the internal lateral ligament extending from the bones of the leg to the calcaneum—thus passing over the astragalus—have caused the last-named bone to be held in part as analogous to an interarticular disk between the bones of the leg on the one hand, and the calcaneum and the scaphoid on the other.

It is interesting in this connection to recall the facility with which persons who have lost the astragalus by excision of this bone after dislocation may yet walk with comparative ease. In such examples the distal ends of the bones of the leg move upon the calcaneo-scaphoid socket after the fashion of the head of the astragalus.

In birds the astragalus is permanently anchylosed to the tibia, so that all the motions between the leg and the foot are such as occur in the human subject in flexion of the ankle between the leg and astragalus as one factor, and the remaining tarsal bones as the other.

The attachments of the ligaments of the ankle-joint are so strong that severe wrenchings will more often result in the separation of the osseous surfaces in connection with the fibres of the ligaments than in rupture of the ligaments themselves. Mr. Callender, who first called attention to this subject, justly believes that the occurrence of such violence to the living bone is an efficient cause in prolonging the reparation of injuries incident to a severely sprained ankle.

In Pott's fracture, in which the fibula is fractured at the lower third, the ankle-joint is of necessity impaired in its functions. The ginglymoid character of the joint is destroyed by the separation of the external malleolar surface from the astragalus. Dr. W. W. Keen has observed that in this fracture the astragalus can be pushed away from its contact against the internal malleolus with ease.

In *talipes equinus* the anterior portions of the lateral ligaments are lengthened, while the posterior are shortened.

Rarely a bursa, lying beneath the internal lateral ligament, communicates with this joint, or with the joint between the head of the astragalus and the scaphoid bone and the calcaneum.

Nerves.—The ankle receives posteriorly a nerve from the posterior tibial nerve, anteriorly one from the anterior tibial.

Arteries.—These are derived from the malleolar branches of the anterior tibial and the peroneal arteries.

The Joints and Ligaments of the Foot.

The bones of the foot are adapted to one another by concave, convex, or flat surfaces, and are held together by ligaments of great strength and variety.

When the weight of the body is borne by the foot, the astragalus is fixed between the malleoli, and functionally acts in this position as a continuation of the tibia in transferring the weight to the remaining tarsal bones.

As a result of this weight there is a disposition on the part of the bones of the tarsus to be pressed downward, the arches of the foot to be destroyed, and the metatarsal bones to spread laterally. Both joint-surfaces and the ligaments tend by their disposition to overcome this tendency, which is still further resisted by the lines of traction of muscles.

The ligaments are all stouter and more varied on the plantar surface and in the interosseous spaces than on the dorsal surface.

The following classification will be followed in this connection:—

The Joints and Ligaments of the Tarsus.

The Joints and Ligaments between the Tarsus and the Metatarsus.

The Inter-Metatarsal Joints and Ligaments.

The Joints and Ligaments between the Metatarsus and the Phalanges.

The Inter-Phalangeal Joints and Ligaments.

The Joints and Ligaments of the Tarsus.

The joints of the tarsus (figs. 2, 8, 5, Plate XLII.) are the following:—

The joint between the astragalus and the calcaneum posterior to the interosseous ligament. It possesses a separate synovial membrane and capsule.

The joint between the astragalus, and the calcaneum in advance of the interosseous ligament, together with

the scaphoid bone and the inferior calcaneo-scaphoid ligament. This extensive and important surface is inclosed by a common synovial membrane.

The joint between the calcaneum and the cuboid bone.

The joint between the scaphoid bone and the three cuneiforms is concave proximally and convex distally. The lateral facets between the cuneiform bones and the cuboid are sufficiently indicated in the description of these bones.

The chief ligaments of the tarsus are—

The External Astragalo-Calcaneal.
The Internal Astragalo-Calcaneal.
The Interosseous.
The Superior Calcaneo-Cuboid.
The Internal Calcaneo-Cuboid.
The Inferior Calcaneo-Cuboid.
The Superior Calcaneo-Scaphoid.
The Inferior Calcaneo-Scaphoid.
The Astragalo-Scaphoid.
The Scaphoido-Cuneiform.
The Scaphoido-Cuboid.

The External Astragalo-Calcaneal Ligament.—This is a small fasciculus attached above to the astragalus, and below is inserted into the calcaneum alongside of the middle fasciculus of the external lateral ligament of the ankle-joint, with which it is often in part confounded.

The Internal Astragalo-Calcaneal Ligament is short, slender, and membranous, and is attached above to the astragalus at the border of the groove for the Flexor Longus Pollicis, and below to the calcaneum.

The Interosseous Ligament (middle astragalo-calcaneal).—This powerful structure occupies the canal between the astragalus and the calcaneum. It is narrow and short medianly, but widens as it approaches the lateral aspect of the foot, where it is superficial. As displayed within the sinus tarsi, the ligament is divided into two portions by a wide interval. The *posterior portion* (posterior interosseous) is a thin but stout fascicle that serves to strengthen the posterior of the two astragalo calcaneal joints. The *anterior portion* (anterior interosseous) is coarser and stouter than the preceding, and unites the superior portion of the anterior process of the calcaneum to a roughened surface on the neck of the astragalus.

The Superior Calcaneo-Cuboid Ligament is a flat band extending from the upper and outer portion of the anterior border of the calcaneum to the corresponding part of the cuboid bone. It is entirely dorsal, and lies to the outer side of the Superior Calcaneo-Scaphoid ligament.

The Internal Calcaneo-Cuboid Ligament (interosseous) is a flat band of great strength attached proximally to the calcaneum, at the sinus tarsi directly within the anterior portion of the interosseous ligament. Distally it is attached to the cuboid bone at the interval between the proximal and the median surfaces. As a rule it is united at its calcaneal attachment with the Interosseous ligament, the two bands forming a V-shaped figure.

The Inferior Calcaneo-Cuboid Ligament is the stoutest and largest ligament of the foot. It is composed of two separate fasciculi or bundles of fibres, which may be known as the greater and the lesser ligament. The *greater ligament*, thicker medianly than laterally, is attached proximally to the entire length of the under surface of the calcaneum in advance of the tubercles. It extends forward in a straight line, and is attached distally to the under surface of the cuboid bone at the tubercle as far as the groove for the tendon of the Peroneus Longus muscle. The ligament strengthens the sheath of the last-named muscle, and sends prolongations to the bases of the fourth and fifth metatarsal bones.—The *lesser ligament* is attached distally to the anterior tubercle of the calcaneum, passes obliquely forward and inward, and is concealed in part by the greater ligament, to be attached to the cuboid bone at the proximo-median angle.

The Superior Calcaneo Scaphoid Ligament (external calcaneo-scaphoid, interosseous) extends from the anterior portion of the calcaneum at the place of origin of the internal calcaneo-cuboid ligament. It is a stout, flat, well-defined band—its superior border lying on the dorsal, and its inferior on the plantar surface—and extends obliquely forward and inward, to be attached to the outer side of the scaphoid bone. Inferiorly it is in contact with the small cartilaginous surface at the medio-plantar angle of the cuboid bone.

The Inferior Calcaneo-Scaphoid Ligament extends as a broad, somewhat radiated structure from the median surface of the calcaneum at the interval between the anterior tubercle and the *sustentaculum tali*, as well as the median borders of the facet of articulation with the astragalus. It passes forward and inward to be attached to the under surface of the scaphoid bone. Its fibres are continuous proximally with those of the deltoid ligament, and distally in part with the cuboidal attachment of the lesser calcaneo-cuboidal ligament. At its upper portion it is thicker than elsewhere, and depressed for the accommodation of the tendon of the Tibialis Posticus muscle which strengthens the ligament, and indirectly supports the

head of the astragalus. Viewed from above, in a foot from which the astragalus has been removed, the inferior calcaneo-scaphoid ligament is seen to form the median and basal aspect of a socket of which the calcaneum and the scaphoid bone form the remaining parts. The ligament is of great strength, and aids in breaking the shock attending the abrupt transfer of the weight of the body through the astragalus upon the foot.

The Astragalo-Scaphoid Ligament is a broad, fine-textured, capsule-like membrane extending from the dorsum of the neck of the astragalus forward over the prominence of the head of the same bone to the dorsum of the scaphoid bone, some of its fibres passing to the second cuneiform. It partly overlies the scaphoido-cuneiform ligaments.

The Scaphoido-Cuneiform ligaments superiorly are distinct flat slips passing from the scaphoid bone to the cuneiform bones. They are best developed on the median border of the foot when the scaphoid and the first cuneiform bone are united. Inferiorly the single stout scaphoido-cuneiform ligament is attached proximally to the tubercle of the scaphoid, and passes in a radiate manner thence to the cuneiform bones.

The Scaphoido-Cuboidal Ligaments present a superior, an inferior, and an interosseous fascicle. The *superior fascicle* is much shorter than the inferior. It passes from the upper and the median part of the superior surface of the cuboid to the scaphoid bone. The *inferior fascicle*—one of the most conspicuous of the plantar ligaments—passes in the form of a flattened cord from the tuberosity of the scaphoid bone forward and outward to the cuboid bone. The *interosseous fascicle* occupies the deep excavation between the scaphoid and the cuboid bones, and is also attached to the third cuneiform.

The three cuneiform bones are held together by short, peripheral, and interosseous ligamentous bands, as in the union of the third cuneiform with the cuboid. They do not demand extended description.

Remarks.—The actions of the ligaments of the tarsus can be best studied by dividing them under the following heads:—

(1) The movement of the astragalus on the calcaneum and the scaphoid bone.

(2) The movement of the calcaneum on the cuboid.

(3) The movement of the medio-tarsal joint.

(1) The weight of the body when thrown upon the foot tends to rotate the astragalus on the fixed calcaneum inward; the head of the first-named bone moves inward and downward on the line of motion afforded by the posterior calcaneo-astragalar articulation. The action is checked by all the ligaments of the ankle-joint, the astragalo-calcaneal, the anterior portion of the interosseous (now horizontal), the superior and the inferior calcaneo-scaphoid which become tense. The astragalo-scaphoid ligament and the posterior portion of the interosseous ligament are relaxed.

When the weight of the body is removed from the foot, as in the supine position, the posterior calcaneo-astragalar articulation is at rest, and the surfaces in part separated. The posterior portion of the interosseous ligament and the astragalo-scaphoid are tense, while the remaining ligaments are relaxed. The head of the astragalus at the same time forms a prominence on the dorsum of the foot.

In the affection ordinarily called "sprained ankle" the ligaments of the ankle and the tarsal ligaments, save two only, are subjected to over-strain. The posterior calcaneo-scaphoid joint suffers more than any other portion of the tarsus, and develops an exquisitely tender spot answering to pressure over the sinus tarsi. Should the ligaments holding the astragalus to the calcaneum and the calcaneum to the scaphoid bone yield, dislocation of the astragalus forward and inward is effected.

(2) When the weight of the body is borne on the foot, as in the erect position, the nearly flat joint between the calcaneum and the cuboid bone becomes entirely engaged. The inferior calcaneo-cuboid ligament becomes tense, while the superior ligaments become relaxed.—In the supine position the joint is at rest, and the surfaces tend to separate from one another. The inferior ligament is now relaxed, and the superior is tense. The astragalo-scaphoid, and both the dorsal calcaneo-cuboid ligaments might now be termed suspensory to the foot beyond the medio-tarsal line.—The prolonged retention of the foot in the position last described constitutes "foot-drop," a complication which is liable to occur in bed-ridden patients when the foot is kept for a long time without support to the medio-tarsal joint. *Talipes equinus* is a variety of "foot-drop."

(3) The action of the medio-tarsal joint is one of torsion about the internal calcaneo-cuboid and the calcaneo-scaphoid ligaments. The torsion is determined by muscles inserted distally to the joint-line. The Tibialis Anticus and the Tibialis Posticus act on the stout median border from the inner side, and turn the sole downward and inward, while the Peroneus Longus, acting on the same line from the outer side, turns the sole downward and outward.—Inward rotation of the astragalus tends to carry the foot inward—an action antagonized by the Peroneus Longus.

When this muscle contracts, while the weight of the body is borne upon the foot, the check ligaments to the motion of the astragalus are made more tense.—The line of motion in torsion is determined at the medio-tarsal joint. When outward torsion is effected without weight being thrown on the foot, the foot is said to be *pronated.* In *talipes valgus* the pronation is extreme and persistent. In pronation the motion is checked by the superior calcaneo-scaphoid and astragalo-scaphoid ligaments. In females pronation is more pronounced than in males. In the motion opposite to the above the foot is said to be *supinated.* The superior calcaneo-scaphoid ligament is relaxed, and the internal calcaneo-cuboid is tense. Supination is the congenital position of the foot. Extreme and fixed supination constitutes *talipes varus.*

The medio-tarsal joint corresponds to nearly a transverse line, so that the foot can here be easily disarticulated.

THE JOINTS AND THE LIGAMENTS BETWEEN THE TARSUS AND THE METATARSUS.

The joints between the tarsus and the metatarsus are three in number:—

One between the first cuneiform bone and the corresponding metatarsal bone. It is convex proximally, concave distally, and longer from the dorsal to the plantar surface than from side to side.

One between the second and the third cuneiform bones and the corresponding metatarsal bones. It is slightly convex proximally, concave distally at its median, but nearly flat at its lateral half.

One between the cuboid bones and the fourth and fifth metatarsal bones. It is concave proximally and convex distally.

Each of the above joints is furnished with a separate synovial sac. The synovial membranes of the tarso-metatarsal articulation are arranged as follows: one sac intervenes between the first cuneiform bone and the corresponding metatarsal bone. The second is a large sac between the second and the third cuneiform bones and the cuboid above, and the outer four metatarsal bones below, between the heads of which it may send small prolongations.

The middle and external cuneiform, and the second and third metatarsal bones may possess a sac separate from that between the cuboid and the outer two metatarsal bones, as seen in fig. 2, Plate XLII.

The ligaments between the tarsus and the metatarsus are—

The Superior Ligaments.
The Inferior Ligaments.
The Interosseous Ligaments.

The Superior (dorsal) Ligaments are seven in number. The most internal of these unites the first cuneiform bone to the first metatarsal. The three following unite the first, the second, and the third cuneiform bone to the second metatarsal bone; a separate ligament passes from the third cuneiform bone to the third metatarsal. Fascicles pass from the cuboid bone to the fourth and the fifth metatarsal bones.

The Inferior (plantar) Ligaments. The crowded condition of the narrowed inferior borders of the second and the third cuneiform bones, together with the corresponding border of the cuboid, renders the inferior ligament less regular than the superior, but it follows the rule of the ligaments of the foot elsewhere in being more powerful. Those uniting the relatively enormous surfaces of the first cuneiform and the first metatarsal, as well as those of the adjoining bones, are stouter than the remaining ligaments. In addition to the above, bands of variable size pass from the first cuneiform to the second and the third metatarsals. The region is protected by the tendons of the Tibialis Posticus and the Peroneus Longus muscles.

The ligaments passing from between the bones at the cuboid-metatarsal joint are unimportant. The most striking is a band of inconstant size extending between the bases of the third and fourth metatarsal bones under the cuboid bone.

The Interosseous Ligaments are two in number—the internal and the external. The *internal*, the longer of the two, extends from the first cuneiform bone to the opposite side of the second metatarsal close to the articular facet. The *external* extends between the outer side of the third cuneiform bone to the inner side of the fourth metatarsal. A slip of this band also passes to its own metatarsal bone.

THE INTER-METATARSAL JOINTS AND LIGAMENTS.

The metatarsal bones are connected with one another at both the distal and the proximal ends.

The ligaments, as in the case of the tarso-metatarsal, are divided into—

The Superior Ligaments.
The Inferior Ligaments.
The Interosseous Ligaments.
The Transverse Ligaments.

The Superior (dorsal) Ligaments are delicate bands directed transversely. The most internal pass from the first to the second bones; the middle from the

third to the fourth; and the external from the fourth to the fifth.

The Inferior (plantar) Ligaments are stronger than the above-named, but resemble them in their general plan.

The Interosseous Ligaments are placed between the opposed surfaces of the metatarsal bones near the proximal extremities. They are weaker than are the ligaments of the tarsus of the same name.

The Transverse Ligaments are names given to loosely fasciculated bands uniting the distal ends of the metatarsal bones.

THE JOINTS AND LIGAMENTS BETWEEN THE METATARSUS AND THE PHALANGES.

These articulations furnish a convex proximal surface well advanced on the plantar region, and a concave distal surface. In the first joint this surface is as broad as high. The motion of flexion is impaired by the position of the sesamoid bones on the plantar aspect.—The proximal surfaces of the remaining joints are compressed laterally.—Each joint is inclosed by a synovial sac and capsule, which are weaker above than elsewhere, and which are greatly strengthened on the sides by cord-like lateral ligaments passing obliquely downward and forward. They are thick inferiorly where they are supported by the tendons of the flexors of the toes.

THE INTER-PHALANGEAL JOINTS AND LIGAMENTS.

The joint-surfaces of these articulations are convex proximally, and concave distally, with the exception of the first inter-phalangeal, where the proximal surface is so far depressed in the centre as to become concave. The joints are well protected on all sides by the synovial sacs and capsules, the latter being strengthened at the sides by the lateral ligaments. Beneath, each joint is supported by a fibrous pad or plate and the underlying tendons of the flexors of the toes. In necrosis of the phalanges, the inferior fibrous pads above mentioned will oftentimes retain the bones in connection with the living parts after all other bands have been destroyed.

Remarks.—The great strength of the first toe enables the ballet-dancer to sustain upon the inter-phalangeal joint the entire weight of the body.—Owing to the disposition of the first metatarso-phalangeal joint, flexion is here imperfectly performed.—This joint is frequently deformed by acquired deflection of the first phalanx outward, and is often the seat of an inflammation communicated to it by a bursa situated above and to its inner side.

The Nerves of the metatarso-phalangeal articulations are derived from the external plantar. Those of the inter-phalangeal joints are derived from the internal plantar.

ALLEN'S

HUMAN ANATOMY.

MUSCLES AND FASCIÆ.

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THE MUSCLES AND FASCIÆ.

GENERAL CONSIDERATIONS.

MUSCLES.

Muscles are the principal organs of locomotion, and are of two kinds, the *voluntary*, which are under the control of the will, and the *involuntary*, which are not. Examples of the first are the muscles of the trunk and limbs; examples of the second are the muscular layers in the walls of the intestinal canal and bloodvessels, including the heart. An imperfectly defined group, the *semi-involuntary muscles*, are thought to be represented in the diaphragm, in the pharynx, and in the lower portion of the rectum. The involuntary muscles are not described in this section, but will be found in the accounts of the viscera and the bloodvessel system.

Myology is the technical word employed to include all subjects relating to the description and properties of muscle.

The Properties of Muscles. The most important of these is contractility. In the voluntary muscles the contractions are followed by intervals of repose. By *muscular tonicity* is implied a state of passive activity that is constantly present during the conscious state. It is illustrated in the manner by which the elevators of the lower jaw act in maintaining contact between the upper and lower teeth even when these muscles are not being influenced by the will. W. Adams happily describes muscular tonicity as a state of vigilant repose.

An abnormal phase of tonicity is met with when a muscle sustains unduly prolonged action of its fibres; under these circumstances a shortening of its belly takes place, which persists as long as the cause of the contraction is maintained. Such abnormal modification of contraction is termed *contracture*.

Contracture of muscle, according to Billroth, is due to disease of the muscles, to primary disease of the nervous system, to loss of antagonism, as well as to the excessive use of one set of muscles over another. Barwell has found that a muscle, owing to its *elasticity*, can be stretched to a distance equal to half of its own length when at rest, but when shortened to a distance in excess of one-fifth of its length, it will be thrown into wavy curves. Stretching of a contractured muscle is readily accomplished and maintained, provided the cause for the contracture be removed. Contracture, clinically considered, is a subject of great importance. In psoas abscess the psoas muscle is contractured, and the thigh is slightly flexed on the pelvis. In lateral curvature of the spine, contracture of the muscles will take place on the side of least curvature. Congenital dislocation of the hip in the same way will excite contracture of the gluteal muscles. Coxalgia will excite contracture of the femoral muscles, etc.

Muscles yield readily to pressure, as from an aneurism or abscess, and easily become infiltrated with the products of inflammation. In caries and necrosis the muscles in connection with the diseased bone undergo atrophy. Any cause of disuse, such as forced inaction, paralysis, etc., will cause muscular atrophy and fatty degeneration.

Muscular tissue is easily affected by conditions of habit and state of health. The terms "strength" and "debility," as ordinarily used, express the degree of the systemic strength or weakness. As judicious use of the muscles causes in them an increase in size, so excessive use or inaction is followed by their decrease in size. Of the complications following local injury, enforced disuse or rest of the muscles is perhaps the most annoying. The muscular fibres become reduced in volume and efficiency, and the synovial fluid both in the joints and along the sheaths of the tendons becomes scanty. After the primary effects of the lesion have disappeared, those created in the muscles will persist.

The Shapes of Muscles. The simplest form of a muscle is that of a *lamina* or *ring*. In either case the muscle is fleshy throughout, and little or no difference is detected between the points of origin and insertion. Diversity in voluntary muscles is established by division of the single lamina into separate thongs or fascicles, and by the variety exhibited in the attachment of these to adjacent parts by means of fibrous sheets or bands. In the involuntary or semivoluntary muscles diversity occurs by the circular fibres about a tube, such as the intestine, becoming spiral or even longitudinal. The change which either a lamina or a ring undergoes in furnishing the patterns for forms more complex than themselves, is said to be the result of its *specialization* or *differentiation*, these terms being used interchangeably.

In those muscles which have been formed by differentiation from laminæ a tendency exists for one or more such fascicles to remain imperfectly separated from the main sheet. When a muscle has two points of origin and but one of insertion, one of the slips of origin is said to be an attempt at the formation of a distinct muscle. Thus, in the Biceps Flexor Cubiti the scapular and the coracoid heads are liable to become distinct, and thus the chief variation seen in the muscle completes the division hinted at by the presence of the second head. This tendency has been formulated under the name of the law of Meckel, which in substance is as follows: The presence of more than one head to a muscle is an indication that such accessory head is in reality the beginning of a process of differentiation of a distinct muscle.

Variations of muscular forms are confined to the following kinds: Variations due to excessive differentiation. Variations in defect or excess. *Cleavage*, by which term is meant a division of a muscular lamina or set of laminæ either longitudinally or transversely. In the former instance the cleavage is parallel to the course of the fibres. In the latter instance it is parallel to the plane of the lamina, and is often spoken of as *planal*. Variations due to imperfect differentiation. *Fusion*, a term of convenience, used here to indicate that two muscles conventionally distinct have united in whole or in part. Compensatory variations, by which one muscle takes the place of another in whole or in part. A muscular bundle arising from one muscle to be inserted in another is said to send to such muscle an *accessory slip;* one receiving a fascicle from another is said to receive a *slip of contribution.*

When a muscle is highly specialized, and fibrous bands connect it to its origin and insertion, the muscular mass is called its *body* or *belly*, and the fibrous bands the *tendon of origin* and the *tendon of insertion* respectively.

The tendon of origin as well as of insertion often passes a variable distance within the belly, and is thus concealed; or it may be displayed upon the surface of the muscle. In either case the fibrous tissue is greatly thinned, and is lost upon the sheath.

Nomenclature of Muscles. When a narrow tendon receives oblique fasciculi upon one side only, such a muscle is called *penniform.*—When the edge of a concealed tendon becomes apparent between divisions of a belly composed of oblique fascicles, such a muscle is called *bi-penniform.*—When a concealed tendon becomes apparent at right angles to the longitudinal axis of the muscle such a muscle is said to possess an "inscription." Some muscles of the body tend to be twisted upon themselves near their insertions. Such a disposition is called *torsion.*—When a tendon is long or well pronounced its action is not necessarily in a straight line with the longitudinal axis of the belly, but may be influenced by angulation about a resisting bony surface. Such muscles are called *trochlear* or *pulley muscles.* The pulley form is not confined to the muscles ordinarily termed trochlear. Many muscles, such as the Obturator Internus, are at all times trochlear, the posterior border of the ascending ramus of the ischium representing the pulley. Other muscles which may be straight in one position will be trochlear in another, as, for example, the Iliacus Internus and the Psoas Magnus, which, while straight in the position of rest, become trochlear when the lower limb is thrown backward, as in running. In the act of swinging the lower limb forward and inward these muscles are again trochlear as far as they are involved. Many trochlear forms are thus temporarily established by bone, and even by sheaths surrounding tendons, bands of fascia, etc.

In addition to the arrangement of muscles according to this degree of complexity, or the manner of their fasciculation, or of the formation of their tendons, they are susceptible of classification by their positions relative to the skin. In this sense the terms *superficial* and *deep* muscles are employed. Superficial muscles embrace all the subdivisions of the great subcutaneous muscle (Panniculus Carnosus), which is well developed in many animals such as the hedgehog and the seal, and of which the little muscles moving the outer ear—the muscles of expression—the Platysma Myoides, etc., are rudiments. The former of these are, as a rule, longer, and possess

more contractile fibres relatively to their size than the deep-seated ones.

Other modifications of a topographical arrangement are implied in the use of such terms as *intrinsic* and *extrinsic*. The Biceps Flexor Cubiti is an intrinsic muscle of the superior extremity; while the Pectoralis Major is an extrinsic muscle, since, notwithstanding its insertion into the superior extremity, it secures its origin from the thorax.

Muscular masses may have a broad origin and a small insertion, such as the Temporal muscle and the Latissimus Dorsi; or they may have a small origin and a large surface of insertion, as the Adductor Magnus; or they may have origins and insertions of nearly equal proportions, as the Masseter.

When a muscle lies above the axis either of the trunk or of a limb it is said to be *epi-axial*, and when below it, *hypo-axial*.

The study of the development of a limb is essential to a correct understanding of the nomenclature of muscles, and of their plan of arrangement. A limb in its earliest expression is a growth from the sides of the body. It projects at the distal end; while the proximal end aids more or less in making up the contour of the trunk. The limb at first carries with it the muscular laminæ of the trunk, but soon the hand or the foot projects through the laminæ, and in the adult state the muscles passing from the body to the limb represent the remnants of the general trunkal layer, as modified by the presence of the limb. The most instructive muscle of this group is the Latissimus Dorsi. In mammals this muscle has points of insertion along the anterior extremity from the bicipital ridge of the humerus to the carpus.

In short-limbed animals there is a tendency for the muscles of the extrinsic group to pass further along the extremity than in the long-limbed animals.

The human subject will sometimes exhibit the extremities in an aborted or imperfect form. In these examples the extrinsic muscles advance further toward the distal end of the limb than is normal.

The Functions of Muscles.—Muscles in the form of specialized circular bands are called *sphincters*. They serve to constrict the tube about which they occur. They are placed at the orifices of tubes, or separate one compartment of a common canal from another. There is usually no muscle antagonistic to a sphincter. When the constricting action is suspended the muscle is said to be relaxed and the orifice to be *dilated*, or *inhibited*.

Muscles are named flexors, extensors, abductors, and adductors, as they influence the joints near which they are placed. *Pronation* is a form of modified flexion. *Supination* is a form of modified extension. Abduction and extension do not essentially differ, nor do adduction and flexion. *Rotation* is a form of adduction or abduction according to the line of traction of the rotating muscles.

Muscles, dilating orifices not guarded by sphincters, are often called *dilators*. Other terms in common use, such as elevators, depressors, etc., do not demand special definitions. The flexors are as a rule stronger than the extensors; they are apt to act more independently, and are less compact in form.

A muscle is powerful in proportion to the number of the fasciculi of which it is composed. The disposition of the fasciculi varies in muscles, and, as stated above, the shapes of the muscles are in great measure determined by this disposition.

Muscles in which the fasciculi are straight, *i. e.*, parallel to the line of the tendon of insertion, are weaker, and move more slowly than do those in which they are arranged obliquely to the line of the tendon. At the same time the oblique fasciculi shorten the muscle more than the straight fasciculi, and require less effort to approximate the points of origin and insertion.

Assuming that both the flexor and the extensor muscles are preserving their tonicity, it follows that the contraction of the muscles of either set must exert a force sufficient to elongate the opposing muscles, as well as to lift the weight of the portion of the limb on which they are inserted. The flexors of the leg, for example, not only exert a degree of force sufficient to raise the bones of the leg and the foot, but must overcome the force exerted by the tonicity of the muscles that extend the leg. This force is known as the antagonistic force, and acts as a check to the degree of contraction of the active set. When this force is withdrawn, either by paralysis or section of the tendon, undue action is at once manifested in the opponents. Some writers describe the muscles opposed to the contracting ones as being relaxed to a degree in exact proportion to the amount of movement in the contracting group.

Muscles in certain positions are said to have ligamentous functions. Their tendons, while crossing joints, will assume to the joint surfaces the character of accessory ligaments, and may be said to differ in function from the intrinsic ligaments of the joint only in being influenced by muscular action. Even when not crossing the joints, but when inserted in or about them, tendons are intimately associated with the

disposition and function of joint surfaces. The shoulder-joints and the knee-joints especially illustrate these statements.

The section on the general consideration of the bones embraces a paragraph on the influence exerted by the muscular system upon the shapes of bones.

The muscles of the subject are usually no longer soft and extensible, but are firm and brittle, either from rigor mortis or from the nature of the preservative agent employed. Careless handling of the subject often lacerates the more tender muscles, as the Psoas Magnus and the Semimembranosus. Care should be taken in studying such material that erroneous conceptions of function be not entertained.[1]

The Number of the Muscles.—The number of muscles in the body, excluding those belonging to the bloodvessel system and alimentary canal, is 229.

They are arranged as follows:—

Muscles of the vertebral column and trunk	51
Muscles of the neck (exclusive of those of the vertebral column)	24
Muscles of the head	37
Muscles of the limbs	117
Upper limb	58
Lower limb	59

The Nerves and Bloodvessels of Muscles.—Muscles are vascular, and, as a rule, abundantly supplied with nerves. Ruge attaches great importance to the manner of nerve termination in muscle. He sees in the pad of protoplasm (see p. 83) evidence in favor of the hypothesis that each muscle is an aggregation of differentiated organs developed about the ends of nerves. From this point of view the study of such terminations becomes a matter of great morphological interest.

[1] According to H. Morris (Med. Chir. Trans., xl. 169), in dislocation of the hip on the dorsum of the ilium, induced after death, the Pectineus, Quadratus Femoris, and Obturator Externus muscles are quite constantly ruptured; the Gemellus Inferior, the Obturator Internus, the Adductor Longus and Adductor Brevis, Pyriformis, Obturator Internus, and the Gluteus Medius less frequently, the last three, indeed, very rarely. How different is this statement from that of Gross (System of Surgery, ii. 95), who says, "the two Obturators, Geminal, Quadratus Femoris, and Pyriform muscles are greatly stretched, and sometimes even partially ruptured." On the other hand, F. S. Eve (Med. Chir. Trans., lxii. 51) found by actual dissection that the only muscles that are apt to be ruptured by this dislocation occurring during life are the Gemelli and the Pyriformis. It is in every way likely that the effects described by Morris were greatly exaggerated by the post-mortem changes in the muscles; it is also conceivable—nay, more than this, it is sufficiently probable to make the observer cautious—that the rough handling of the cadaver which has been the subject of unreduced dislocation may cause rupture in muscles already over-tense and in a state of rigor mortis, and that the defection of such ruptures should be accredited to the primal effects of the displacement. How can ante-mortem rupture be distinguished from post-mortem? As a rule easily, viz., by the presence of blood-clot or blood-infiltration in the former instance, and its absence in the latter.

A CLASSIFICATION OF MUSCLES.

1. The muscles of the Head, Neck, Trunk, and Limbs—
   - I. The Muscles of the Head.
   - II. The Muscles of the Neck.
   - III. The Muscles of the Trunk.
   - IV. The Muscles of the Superior Extremity.
   - V. The Muscles of the Inferior Extremity.
2. The Muscles of the Alimentary Canal—
   - I. The Muscles of the Pharynx.
   - II. The Muscles of the Anal Region.
3. The Muscles of the Larynx.
4. The Muscles of the Genital Apparatus—
   - I. The Muscles of the Male.
   - II. The Muscles of the Female.

FASCIA.

The term fascia is given to a thin sheet of fibrous or connective tissue which is ordinarily appended to the muscular system or to the general integument, and which serves in the limbs as sheaths to muscles, or as a surface for muscular attachment, and in the cavities of the body for the general protection of the viscera. The fasciæ of the limbs and of the parietes of the trunk are divided into the superficial and the deep.

The *superficial fascia* is subcutaneous, and more or less intimately associated with the skin by means of delicate bands or trabeculæ. In some regions, as at the groin, several layers of this fascia can be demonstrated. Frequently loaded in health with adipose tissue, as at the buttock or on general limb-surfaces, it may also be without fat, as in the eyelids and the scrotum. The fasciæ are absent in the face and the scalp. In the former region the subcutaneous fat is not divisible into layers, the Buccinator muscle alone among all the facial muscles having a fascia-like covering.

The superficial fascia and the fat form together with the skin an envelope of the limbs of variable thickness, which, excepting at the joints, enables considerable motion to take place between the superficial and the deep fasciæ. In emaciated subjects the fat of this layer is absorbed, when the skin forms wrinkles or hangs in folds.

The *deep fascia* gives shape to the limbs, furnishes

points of attachment to muscles, and often determines the lines of their traction. It aids in forming intermuscular bands as in the Digastric muscle, or intermuscular sheets as in the Occipito Frontalis. It sends slips of attachment to strengthen the tendons of muscles, as in the Biceps Flexor Cubiti and the Latissimus Dorsi, and also gives definition, as in the thigh and the neck, to canals for bloodvessels and nerves.

Slips of fascia are often of importance in ascertaining the significance of muscular variations. Thus the internal brachial ligament (*q. v.*) is a fold of deep fascia which represents a muscular tract in some of the quadrupeds, and which may even become so in man.

The transition of folds of deep fascia into ligaments is evident in the neighborhood of joints, the capsules of which are thus strengthened. Examples of such fascia-like extensions are seen passing from the tendons of the muscles about the hip-joint to its capsule.

Belonging to the group of the deep fascia is a loose connective tissue layer lying between the parietal peritoneum and the adjacent parts. It is properly a sub-peritoneal connective tissue, and communicates with the thigh at about the insertion of the Psoas Magnus, with the hip-joint through the bursa iliaca, and with the buttock through the ischiatic foramen. Above it constitutes the retro-peritoneal space. A very useful method of studying this fascia in connection with the behavior of a quantity of pus lying within it is to inject the sub-peritoneal space with water, as recommended by Koenig.[1]

The following terms are used in describing fasciæ: The envelope of a muscle is called its *sheath.*—The sheath of a tendon is called its *theca* or *vagina.*—Under the name of *retinacula* are described bundles of fascia pertaining to the ligaments. They aid in determining the lines of traction of important muscles. The posterior portion of the capsule of the knee-joint exhibits two examples of the retinaculum. One of these extends from the head of the fibula to the capsular ligament, and assists the Popliteus muscle in maintaining traction upon the last-named structure. A second example of a retinaculum is seen where the oblique band of the same ligament receives some of the fibres of insertion of the Semimembranosus muscle.—A layer of fascia having a well-defined broad surface of attachment, especially when readily demonstrable, is called an *aponeurosis.* This term is restricted to a sheet of deep fascia which is set apart for a special use, and which is ordinarily accessory to muscular action.—A layer of fascia placed between two or more muscles, and affording points of attachment for them, is called an *intermuscular septum.*

A synovial chamber yields a glairy fluid called synovia, whose function in the fasciæ is to prevent friction, as between a tendon and its sheath. When it is in the form of a rounded sac, lodged between two opposed muscular or tendinous surfaces, the synovial chamber is called a *bursa.* The membranes forming the sheaths of tendons, according to Brodie, have the same structure as have those of other bursæ (the bursæ proper of Bichat), and cannot be distinguished from them.

Fascial bands assist in strengthening joints, when they are termed ligaments; such as the annular ligament of the wrist-joint. In this way they often act as pulleys to adjacent muscles.

Fascia, like all forms of fibrous and connective tissue, shrink when not in use. When muscles lose in volume the sheaths shrink, and when they gain the sheaths enlarge to accommodate them. The sheaths, however, cannot follow the muscles beyond a certain point. Hence the feebleness of an emaciated person; this feebleness arises not only from the loss of muscular force, but from the inability to economize muscular force by the aid of the opposed sheaths.

Long-continued malposition of a part may gradually induce shortening and shrinkage of fibrous tissue. The plantar fascia thus shortens in club-foot. Some curious examples of shrinkage are met with in the palmar fascia, which in elderly persons will sometimes end in marked deformities through forced flexion of the fingers. The fascia lata shortens in limbs in which the thigh has been for a long time flexed, and it can always be felt, in the emaciated, as a cord-like band extending downward from the crest of the ilium.

A layer of fascia is frequently a means of influencing morbid processes, either fixing them by anatomical limitation, or furnishing them the means of extending from one region to another. Fascia in the form of an intermuscular septum may act as a barrier to diffuse suppuration, but in the form of a synovial sheath it may facilitate the spread of inflammation. Butcher[1] believes that non-malignant growths differ from malignant in not incorporating adjoining tissues into their structure. Thus a cancer will involve by

[1] Lehrbuch, der Spec. Chirurg., Band II.

[1] Operative and Conservative Surgery, 255.

its growth surrounding parts; while a fibrous tumor by its increase will displace the surrounding tissues, or cause them to atrophy.

Gendrin[1] has observed that when the subserous cellular tissue, which always participates in the inflammation of a serous membrane, penetrates into the interior of an organ, it becomes a ready means of communicating the inflammatory action; but when the contiguous organ or subjacent part is of a structure different from that of the cellular tissue the extension inward is checked.

I. THE MUSCLES OF THE HEAD.

The muscles of the head form four groups—

The Muscles of the Face.
The Muscles of the Auricle.
The Muscles of the Orbit.
The Muscles of Mastication.

The Muscles of the Face.

The muscles of the face are divided into three sets: The fronto-palpebral; the nasal; and the oral groups.

The Fronto-Palpebral Group is composed of—

The Occipito-Frontalis.
The Pyramidalis Nasi.
The Orbicularis Palpebrarum.
The Corrugator Supercilii.

THE OCCIPITO-FRONTALIS.

This muscle consists of two portions—the occipital and the frontal—separated by an aponeurosis. The occipital portion arises from the outer two-thirds of the superior semi-circular line and from the mastoid portion of the temporal bone. It ascends a short distance (about two inches) to terminate in the aponeurosis. The frontal portion arises from the aponeurosis near the frontal eminence, and passes downward to be inserted into the brow, becoming thence continuous with the Pyramidalis Nasi. Both portions are thin, sheet-like expansions of muscular tissue, the occipital, however, being less intimately associated with the skin than the frontal.

The aponeurosis—the epicranial aponeurosis or galea aponeurotica—is a beautiful fibrous expansion uniting the occipital and frontal portions of the Occipito-Frontalis, and inclosing the crown of the head as a cap. It is intimately associated with the scalp above (a sparse distribution of granules of fat here and there intervening), a tedious dissection being required to separate them. It is very loosely attached to the pericranium, a little loose connective tissue alone intervening. Laterally the aponeurosis is gradually lost in the superficial temporal aponeurosis, and affords attachment to the Attollens and Attrahens Aurem muscles.

Use.—The Occipito-Frontalis elevates the brows in conjunction with the Pyramidalis. The conjoined action of the inner portions of both muscles may depress the median portion of the skin of the forehead. To secure this action the lateral part of the muscle must be active in elevating the brow.

Some individuals, by the alternate contraction of the occipital and frontal portions, are able to move the scalp backward and forward.

THE PYRAMIDALIS NASI.

This muscle, as already stated, is a continuation of the frontal portion of the occipito-frontalis muscle downward upon the nose, where it terminates in an aponeurosis in common with the origin of the Compressor Naris.

THE ORBICULARIS PALPEBRARUM

is, as the name expresses, the muscle of the eyelids. It, moreover, surrounds the orbital margins, and encroaches slightly upon the temple and the face. It thus consists of two portions, the palpebral covering the lids, and the orbital surrounding the orbit.

The palpebral portion arises from the palpebral ligament, and describes an ellipse entirely upon the lids.

The orbital portion arises from the inner border of the orbit at the nasal process of the superior maxilla. Its ellipse is interrupted at the brow by the fibres of the occipito-frontalis muscle. Below an oblique fasciculus passes downward and inward from the outer border of the muscle to the Levator Labii Superioris. While the inner and upper borders are fixed, the lower and outer are free. The fasciculi at the brow are short and compact, but those overlying the external angular process and the malar eminence are long, and exhibit a looser texture.

Use.—By the palpebral fibres to elevate the lower eyelid and to depress the upper. By the orbital fibres to act as a sphincter to the region about the lids. The former fibres are involuntary, while the latter are under the control of the will.

[1] Histoire Anatomique des Inflammation, i. 314.

According to Roser, the anterior layer of the inner division of the Orbicularis Palpebrarum dilates the lachrymal sac, while the posterior layer serves apparently to compress it.

The so-called tendon of the Orbicularis runs transversely over the middle of the lachrymal sac; consequently, when this is swollen, the resulting tumor appears sometimes to be divided into an upper and a lower portion.

THE CORRUGATOR SUPERCILII.

This muscle arises from the supra-ciliary ridge near its inner part, passes outward and upward, and is inserted into the brow. It is a small muscle, and is probably an imperfectly isolated group of fasciculi belonging to the preceding muscle.

THE TENSOR TARSI.

The Tensor Tarsi (Horner's muscle) is a deep fascicle of the ciliary fibres of the Orbicularis Palpebrarum. It arises from the lachrymal bone behind the lachrymal sac, and divides into two portions, a superior and an inferior. Each portion follows the direction of the lachrymal canal adjacent to it, and is lost on the structures about the median border of the corresponding tarsal cartilage.

The Nasal Group includes the following muscles:—

The Compressor Naris.
The Depressor Alæ Nasi.
The Dilator Naris Anterior et Posterior.

The Compressor Naris, the Depressor Alæ Nasi, and the Dilatores Naris are unimportant fascicles whose actions are implied in the names they bear.

The Compressor Naris arises by a narrow surface from the canine fossa of the superior maxilla. The fibres diverge from one another, and are inserted on a fibrous expansion at the side of the nose. This muscle descends to the alveolar line, and lies to the outer side of the Depressor Labii Superioris, and on nearly the same plane with the Levator Anguli Oris.

The Depressor Alæ Nasi arises from the superior incisive fossa of the superior maxilla, and is inserted into the integument over the nasal septum. A few fibres pass to the ala as well.

Indistinct fibres of the Dilatores Naris pass between the cartilages of the ala and the integument.

The Oral Group is composed of—

The Orbicularis Oris.
The Levator Labii Superioris Alæque Nasi.
The Levator Labii Superioris Proprius.
The Zygomaticus Major.
The Zygomaticus Minor.
The Levator Anguli Oris.
The Depressor Labii Superioris.
The Depressor Anguli Oris.
The Levator Labii Inferioris.
The Mentalis.

THE ORBICULARIS ORIS

is a thin layer of muscular fibres surrounding the mouth. It sends slips upward to the nose, and receives the remaining muscles of the oral group and the Buccinator. The labial fibres are continuous around the angle. Slips are sent off from the muscle to the septum and alæ of the nose.

Relations.—The skin is intimately associated with the muscle in front, while the mucous membrane overlies it behind. It is supplied by branches of the facial nerve and the fifth pair, and receives a coronary branch of the facial artery.

THE LEVATOR LABII SUPERIORIS ALÆQUE NASI

arises from the nasal process of the superior maxilla near the inner border of the orbit, where some of its fibres are continuous with those of the Orbicularis Palpebrarum. It passes downward, and is inserted upon the wing of the nose and the upper lip.

THE LEVATOR LABII SUPERIORIS PROPRIUS.

This muscle arises from the lower edge of the inner third of the orbit, from the superior maxilla, and from the malar bone. It passes downward to the upper lip. Lying upon the same general plane as the muscle last described, it is often united with it.

Relations.—The muscle lies just beneath the skin, but is overlapped above by the lower fibres of the Orbicularis Palpebrarum. Beneath it lie the infraorbital nerve and blood-vessels, and the Levator Anguli Oris.

THE ZYGOMATICUS MAJOR.

The Zygomaticus Major arises from the malar bone, and passes downward and forward to be inserted into the angle of the mouth.

THE ZYGOMATICUS MINOR.

The Zygomaticus Minor arises from the superior maxilla between the two last-mentioned muscles, and passes downward, parallel with the Zygomaticus

Major, to be lost in the upper lip near the angle. It is often only a slip of the Orbicularis Palpebrarum, and is frequently absent.

THE LEVATOR ANGULI ORIS.

The Levator Anguli Oris arises from the superior maxilla at the canine fossa, and passes downward and slightly outward to the angle of the mouth.

THE DEPRESSOR LABII SUPERIORIS.

The Depressor Labii Superioris arises from the superior maxilla at the incisive fossa, and passes upward to the lower border of the nostril, and to the septum between the nostrils. It can be best displayed by removing the mucous membrane from the upper lip. It constitutes in part the M. Nasalis of Henle.

THE DEPRESSOR ANGULI ORIS

arises by a broad base from the external oblique line at the basal portion of the lower jaw. It narrows as it passes upward, and is inserted into the angle of the mouth.

THE DEPRESSOR LABII INFERIORIS

arises from the lower jaw, between the symphysis and the mental foramen, and passes upward to the lower lip. Its fibres are interspersed with fat.

THE MENTALIS.

The Mentalis muscle arises from the alveolar processes of the lower incisor teeth, and passes radially outwards to the skin. It can be displayed by making an antero-posterior incision from the skin to the bone.

THE BUCCINATOR.

This muscle, ordinarily included in the facial muscles, or muscles of expression, belongs more properly to the pharyngeal constrictor group. It may be said to be projected from this group into the face. It arises from the pterygo-maxillary ligament, and from the alveolar line of both the upper and the lower jaw, opposite the position of the molar teeth. Its fascicles pass forward to be inserted into the angle of the mouth. A partial interlacing of the upper and the lower sets of fasciculi is noticeable.

Relations.—This muscle is remarkable for being covered by a thin fascia, thus distinguishing it from the other facial muscles. It is pierced by the parotid duct opposite the second molar tooth. In well-nourished individuals a lobule of soft fat lies between the Buccinator and the fat of the skin, and is continued upward between this muscle and the Masseter.

THE FASCIA OF THE MUSCLES OF THE FACE.

The skin of the face and of the vault of the cranium is not separated from the fat which lies beneath it; nor are the muscles ensheathed, but, instead, the fat and muscles are intricately associated.

This absence of fascia is compensated for by cushiony masses of connective tissue, which are conspicuous in the following localities: the hollow of the cheek; beneath the Zygomaticus, and over the Buccinator muscle, especially near the root of the coronoid process; beneath the lower fibres of the Orbicularis Palpebrarum, particularly where it overlaps the elevators of the upper lip; between the latter group of muscles and the elevators of the oral angle; at the groove for the facial artery as it passes over the lower jaw; and at the symphysis menti beneath the depressor of the lower lip.

The skin of the face is everywhere thin, so that its scars are as a rule inconspicuous. A very different result follows extensive cicatrization of the deeper parts. Here the connective tissue is abundantly present, and, as seen after ulcerations from mercurial sore mouth, or after destructive stomatitis from any cause, serves to contract the oral fissure, and, as it were, to convert the cheeks into false ligaments holding the jaws close together. Anchylosis of the temporo-maxillary articulation, as a result of such contraction, is of common occurrence.

In conditions more closely approximating the nor-

EXPLANATION OF PLATE XLIII.

Fig. 1. The muscles of expression.
Fig. 2. The temporal muscle.
Fig. 3. The muscles of the side of the face and the neck.

OCCIPITO
FRONTALIS
Frontal portion
CORRUGATOR SUPERCILII
ORBICULARIS
PALPEBRARUM
PYRAMIDALIS
LEVATOR LABII SUPERIORIS ALÆQUE NASI
ZYGOMATICUS MIN.
ZYGOMATICUS MAJ.
OBRICULARIS
ORIS
DEPRESSOR ANGULI ORIS
PLATYSMA MYOIDES
DEPRESSOR LABII INFERIORIS
LEVATOR LABII INFERIORIS
LEVATOR ANGULI SUPERIORIS
MASSETER

Sup. Temp. Fascia
Sup. Temp. Fascia
TEMPORAL MUSCLE
Superficial portion
Deep portion
Deep Temp. Fascia in position
Sup. Temp. Fascia
Deep Temp. Fascia reflected

OCCIPITO FRONTALIS
Tendinous aponeurosis
Occipital portion
ATTOLENS AURUM
Frontal portion
ORBICULARIS
PALPEBRARUM
ZYGOMAT. MINOR
ZYGOMAT. MAJOR
MASSETER
ORBICULARIS ORIS
DEP. ANGULI ORIS
PYRAMIDALIS
COMPRESSOR NARIS
LEV. LABII SUPERIORIS ALÆQUE NASI.
DEP. LABII INF.
BUCCINATOR
RETRAHENS AUREM
COMPLEXUS
TRAPEZIUS
SPLENIUS CAPITIS
LEV. ANG. SCAPULÆ
SCAL. MED.
STERNO-CLEIDO MASTOIDEUS
PLATYSMA MYOIDES
Line of Platysma

mal, as in facial ecchymosis or emphysema, it is seen that a free communication by means of the connective tissue exists between the neighboring parts and the region of the muscles of expression. *Ecchymosis* is commonly limited to the injured spot, but sometimes, as in old persons, it may be extensive. After fracture of the jaw ecchymotic swelling may rapidly spread from the point of lesion downward under the skin of the neck and chest, upward to the cheek, and to the lower eyelid of the opposite side, as well as inward to the mucous membrane both of the hard and of the soft palate.

Emphysema of the face is more rare. It may follow fracture of the frontal bone over the sinus, when it will be limited to the parts about the forehead; or an ulcer of the mucous membrane may give rise to it. T. P. Heslop[1] narrates a case of fatal emphysema in a boy aged four years, who, while recovering from measles, suffered from ulceration at the angle of the mouth. The air-distended connective tissue extended from this point downward along the entire length of the trunk. At the autopsy it was found that the mucous membrane at the oral angle was separated from the integument, so that the handle of a scalpel could be inserted nearly an inch into the cheek.

The Fat of the face is abundant beneath the cheeks, but is sparsely distributed upon the lips, the nose, the eyelids, and the forehead. The fibres of some of the muscles are interspersed with lobules of fat, as is well seen in the depressor of the lower lip. As a rule, however, the fat lies beneath the skin and around the more superficial muscles, or is less uniformly distributed among the deeper muscles. A pad is quite constantly found beneath the quadrate elevator of the upper lip and the elevator of the oral angle; and a second between the latter muscle and the bone about the infra-orbital nerve.

The fat presents a granulated appearance in the infant. The fulness of the cheek in the young is not due to the superficial layer alone, but to the deeper-seated mass lying partly upon the Buccinator and partly upon the Masseter muscle. The latter-named mass has received the name of the "button" from its figure, which is abruptly constricted at its base, where it is continuous with the fat of the temporal fossa.

The "button" is surrounded by capsule-like connective tissue, and is crossed by branches of the transverse facial nerve. As a natural result of the prominence of the cheek in a young child, a fall upon the face is apt to result in its injury. If laceration should involve the "button," this structure may appear, according to Boyers,[1] between the lips of the wound.

In *facial œdema* the degree of effusion of serum into the tissues of the region of expression will be naturally determined by the distribution of the fat and the connective tissue. In determining the degree of impairment in the return of the venous blood upon which the occurrence of œdema depends, it is found that the amount of facial œdema bears an exact relation to the amount of involvement of the submucous connective tissue. In the familiar instance of swelling of the face accompanying an alveolar abscess, the exciting cause lies within the alveolar process, which transmits the irritation to the submucous connective tissue, and thence to the cheek.[2]

When the œdema is excessive, as in erysipelas, the buccal and the labial tissues will be first affected. The lips will be everted and thickened, and the eye closed, more, however, by the pushing upward of the lower eyelid by the engorged buccal tissues than by any change in the structures of the upper eyelid.[3] In the swelling of decomposition the lips become greatly everted, and the lower eyelid puffed up. These are due to both of the causes above mentioned.

The position of local œdema of the forehead is determined as follows: The resistance on both sides furnished by the skin without and the pericranium within is so great that the swelling assumes a flattened form, and gravity will aid it in taking a position below its point of origin. Thus, in a person stung on the forehead by a bee, the greater amount of swelling takes place *below* the injured point.

[1] Med. Times and Gaz., 1868, 638.

[1] Med. Times and Gazette, 1868, 138.

[2] Involvement of a mucous surface tends to the formation of submucous œdema in all instances. In the intestines, however, the presence of a serous covering materially modifies the process, and indeed the fluid is forced, through increased activity of the follicular glands, directly into the alimentary canal. The process is also modified in the trachea and the bronchial tubes. In the mouth, the nose, the pharynx, and the parts about the glottis, there is no such limitation, and œdema is developed at once in the submucous tissue.

[3] Another example of submucous œdema is seen in the conjunctival chamber. A very slight degree of irritation will cause in this region protrusion of the conjunctival membrane, which, when the irritation is excessive, is seen to escape from the palpebral chamber and to lie as a red and thickened fold between the lids. This condition is recognized as *chemosis*. Persistent chemosis leads to general infiltration of the structures of the lids when the subcutaneous tissues become involved. This, however, is not common except in severe general ophthalmia. It is an interesting fact that a subcutaneous œdema may be dependent upon one which primarily was of submucous origin.

In a case of necrosis of the frontal bone, where the offending fragment was situated near the frontal eminence, the writer found the associated œdema near the median line at the brows. Such a collection is very deceptive. Its resisting boundaries give to the fluid the physical signs of an abscess, and if it is associated with redness of the skin the incautious may needlessly open it.

Paget[1] believes emphysema of the forehead to be a common sign in fracture of the frontal bone involving the frontal sinus.

The Fascia of the Side of the Face.—Immediately beneath the skin of the temple is a well-defined though thin layer of fat, which is continuous with that covering the parotid gland. On the temple this fat is in intimate association with the superficial temporal fascia and its continuation downward into the so-called parotid fascia. The manner of the connection of this fascia with the tendon of the Occipito-Frontalis and with the auricular muscles is worthy of careful study. With a little care it can be lifted from the parotid gland so as to include within it the superficial lamina of the masseteric fascia, the deep lamina being continuous with the cervical fascia. This arrangement would point to the conclusion that the masseteric fascia is derived from below (deep layer), as well as from above (superficial layer). Between them passes the transverse facial branch of the temporal artery. Filaments of the facial nerve lie also in this position. By tracing the filaments backward, or by freely elevating the fascia and the superficial lobules of the parotid gland from the position of the venules which are constantly found lying directly in front of the auditory meatus, the entire *pes anserinus* of the facial nerve can be displayed. The position of the firm masseteric fascia prevents the Masseter muscle receiving its arteries and nerves from in front. The entrance of the artery into the muscle at the sigmoid notch caused Velpeau[2] to assert that in dislocation of the lower jaw the vessel is of necessity compressed.

The Muscles of the Auricle.

The Auricular Muscles—namely, those that are inserted into the auricle—are three in number:—

The Attollens Aurem.
The Attrahens Aurem.
The Retrahens Aurem.

[1] Med. Times and Gaz., 1867, 251.
[2] Chirurg. Anat., i. 80.

THE ATTOLLENS AUREM.

The Attollens Aurem arises from the superficial temporal fascia by a broad fan-shaped origin. It is a thin band of pale fibres, which narrows to a small point of insertion upon the upper surface of the auricle near the external meatus.

The Nerve-supply is secured from the small occipital.

THE ATTRAHENS AUREM.

This small flat muscular fasciculus arises from the superficial temporal fascia in front of the auricle, and is inserted into the tragus.

The Nerve-supply is derived from the facial and the auriculo-temporal branch of the inferior maxillary.

THE RETRAHENS AUREM.

The Retrahens Aurem, stouter than the remaining muscles of the group, is composed of two or three separate fascicles. It arises from the temporal bone at the mastoid portion, and passes forward, slightly narrowing as it is inserted into the posterior aspect of the auricle. It lies on the same plane as the occipital portion of the Occipito-Frontalis muscle.

The Nerve-supply is derived from the posterior auricular branch of the facial.

Remarks.—The above are all rudimentary forms of larger muscles found in the lower animals. They are, as a rule, not under the control of the will, and usually are incapable of moving the external ear. The first two would appear to assist in maintaining lateral traction upon the epicranial and temporal aponeuroses.

The Muscles of the Orbit.

The Muscles of the Orbit are as follows:—

The Levator Palpebræ Superioris.
The Superior Rectus.
The Inferior Rectus.
The Internal Rectus.
The External Rectus.
The Superior Oblique.
The Inferior Oblique.

THE LEVATOR PALPEBRÆ SUPERIORIS.

The Levator Palpebræ Superioris arises from the upper margin of the optic foramen, as a narrow,

ribbon-shaped band. It passes forward, expanding as it does so, and is inserted upon the anterior surface of the upper tarsal cartilage.

In the case of a boy aged five years, this muscle was found by Dr. J. Green[1] torn completely across, with resultant falling of the upper eyelid. After an interval of two years the retracted end of the muscle was attached to the tarsal cartilage, and its function entirely re-established.

THE RECTI AND OBLIQUE MUSCLES.

The four Recti muscles can be considered together.

They arise from the borders of the optic foramen, diverging thence as straight flattened bands, and are inserted by tendinous fibres in the sclera, two or three lines from the border of the cornea.

The Superior Rectus is the weakest, and is separate from the others, which have an origin almost in common.

The External Rectus is the strongest of the muscles of its group. It commonly arises in two portions, the lower of which secures a small attachment from the lower edge of the sphenoidal fissure; through which opening the third and the sixth cranial nerves pass, together with the naso-ciliary branch of the fifth nerve and the ophthalmic vein.

In some cases of single convergent strabismus the Internal Rectus of the squinting eye is much smaller than its fellow of the opposite side.

The Superior Oblique also arises at the border of the optic foramen. It extends to the upper inner angle of the orbit, and becomes tendinous as it passes round the trochlear process of the frontal bone. Beyond this point the muscle again assumes a fleshy appearance, is deflected backward and outward, and is inserted upon the sclera beneath the insertion of the Superior Rectus, at a point midway between the Superior and the External Recti muscles, and nearly equidistant from the cornea and the entrance of the optic nerve.

Budge[2] describes a variety of the Levator Palpebræ Superioris in which a bundle of filaments joined the Superior Oblique muscle.

Relations.—Above is the roof of the orbit; beneath lie the nasal nerve and the Internal Rectus muscle; the fourth nerve enters the upper surface. A minute bursa is situated beneath the tendon of this muscle as it passes the trochlea.

[1] Trans. Am. Oph. Soc., 1871, 134.

[2] Zeit. für. rat. Med., 1859, 273.

The Inferior Oblique muscle arises from the inner end of the floor of the orbit. It passes beneath the terminal portion of the Inferior Rectus above, and behind to the outer surface of the sclera, upon which it is inserted between the entrance of the optic nerve and the tendon of the External Rectus.

Uses.—The Superior Rectus muscle moves the eyeball upward.—The Inferior Rectus moves it downward.—The Internal Rectus moves it inward.—The External Rectus moves it outward.—The Superior Oblique rotates the eyeball, and moves it downward.—The Inferior Oblique rotates the eyeball, and moves it upward. Both the oblique muscles, when acting together, can draw the eyeball slightly forward.

The Superior and the Internal Rectus acting together will draw the eyeball in a direction neither upward nor inward, but in a line between. In like manner the combined action of any two related muscles will move the eyeball in a direction between the lines of traction of the muscles acting separately.

The function of the Levator Palpebræ muscle is antagonized by that of the Orbicularis Palpebrarum. In the normal status resulting from the harmonious action of the two muscles the upward movement of the eyelid is less pronounced than when this harmony is destroyed by paralysis of the Orbicularis. In facial palsy, for example, the upper eyelid of the affected side is raised a little higher than the other. The Levator is relaxed when the eyelids are closed.

The capsule of Tenon is a name given to a fibrous envelope of the sclera. It arises from the borders of the orbit, passes behind the conjunctiva to the corneal border, and covers the eyeball from that point as far as the entrance of the optic nerve. It is pierced by the tendons of the periocular muscles, and permits rotation of the ball to take place within its embrace.

From the outer surface of the capsule delicate processes can be traced along the course of the muscles, and from its peripheral connections with the walls of the orbit septa pass, to strengthen the lachrymal sac and eyelids on the inner side, and the external palpebral ligament on the outer.

THE PERIOCULAR SPACE.

This space is defined by the eyeball and the walls of the orbit, and may be said to include the contents of the orbit; the eyeball, and the optic nerve, as it lies within the orbit, alone being excepted. The space is occupied by delicate connective tissue and fat, and being enclosed measurably by the capsule of Tenon

is conveniently included under the same heading with the fasciæ of the head and face.

The periocular space is of interest from the variety of ways in which it may be involved in lesions of the neighboring parts. The inflamed lachrymal gland will press upon it, and the pus from a glandular abscess may flow into it. Abscess of the frontal sinus may also implicate it, as may the inflammation attendant upon ostitis or necrosis of any portion of the orbital walls. Distension of the maxillary sinus may narrow the orbit by elevation of its floor, and thereby alter the normal relations of parts within the periocular space.

The Movements of the Eyelids.—The lids in great measure follow the lines of motion of adjacent facial and orbital muscles. If the elevation of the upper lid is decided, it is always accompanied by elevation of the brows and by upward movement of the eyeball. The lower eyelid also moves upward slightly in the movement just described. W. R. Gowers[1] ascribes this to the pressure of the lower convexity of the sclera against the tarsal cartilage, a pressure which can be readily seen or felt if the finger is placed upon the lower eyelid during the movement. In like manner the downward motion of the eyeball tends to draw the upper eyelid downward. The two last-mentioned motions being accompanied with rotation of the eyeball, it follows that at least one of the uses of the oblique muscles is to secure, in the rotation and the slightly protruding motion above mentioned, such pressure against the eyelids as to permit of these secondary motions. As the upper eyelid descends the lower eyelid ascends slightly, and is drawn inward.

The Nerves of the Superior Rectus, Inferior Rectus, Internal Rectus, Inferior Oblique, and Levator Palpebræ are secured from the third cranial nerve. The motor nerve of the Superior Oblique is derived from the fourth cranial nerve, and that of the External Rectus from the sixth. To the ophthalmic branch of the fifth nerve is due the general sensibility of all the muscles of the group.

[1] Med. Chir. Trans., lxii. 432.

The Muscles of Mastication.

These comprise—

The Masseter.
The Temporal.
The Internal Pterygoid.
The External Pterygoid.

They are all powerful muscles inserted into the ramus of the lower jaw, and supplied by the inferior maxillary division of the fifth cranial nerve.

THE MASSETER.

The Masseter is a stout quadrilateral muscle extending from the zygomatic process to the outer surface of the ramus of the lower jaw. It is composed of two portions, the superficial and the deep, of which the former is the larger and stronger. The superficial part arises by tendinous fibres from the anterior two-thirds of the zygomatic arch and the lower margin of the malar bone, and passes downward and slightly forward to be inserted into the lower half of the ramus and the angle of the jaw upon its outer side. The deeper layer is tendinous below, namely, at the line of insertion, and is less obliquely situated than the superficial. The posterior edge of the muscle exhibits a separation into two layers, but at the anterior edge these layers are united. Monro described a bursa lying in the pouch-like space between the two layers.—The anterior border of the Masseter, formed, as already mentioned, of both layers, is thick and columnar. It can be readily felt by the finger inserted between the cheek and the malar bone. The division of the muscle at this point for false anchylosis of the temporo-maxillary articulation could be better secured by a submucous than by a subcutaneous myotomy.[1]

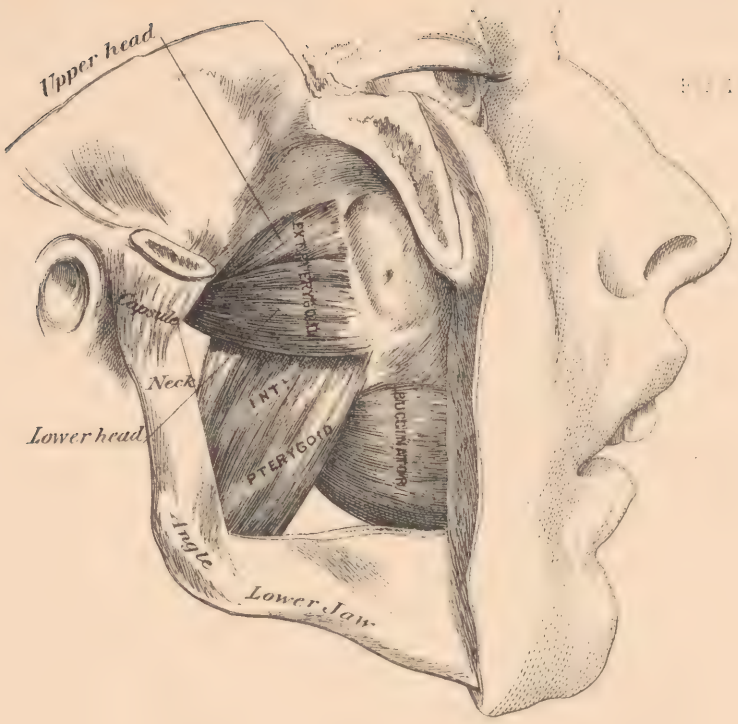
Dr. Dixon[2] describes an instance in which sloughing of this muscle followed intense traumatic inflammation.

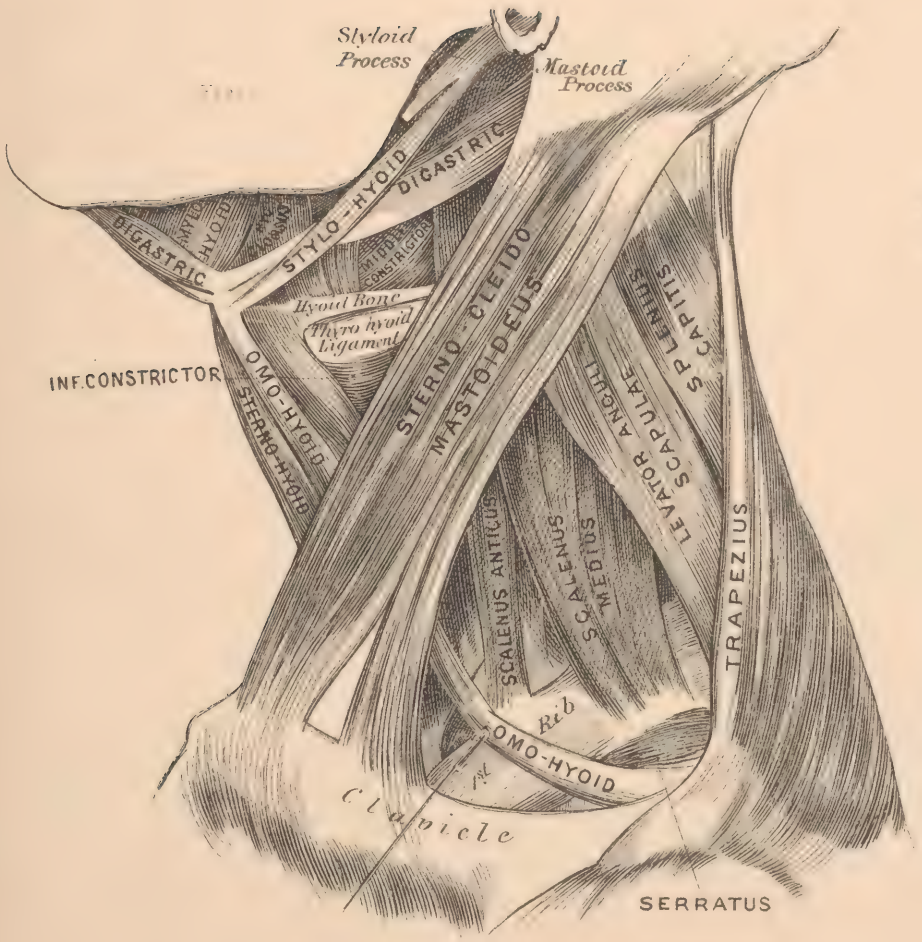
Relations.—The muscle is covered by the masseteric fascia (which adheres intimately to the tendon of origin)

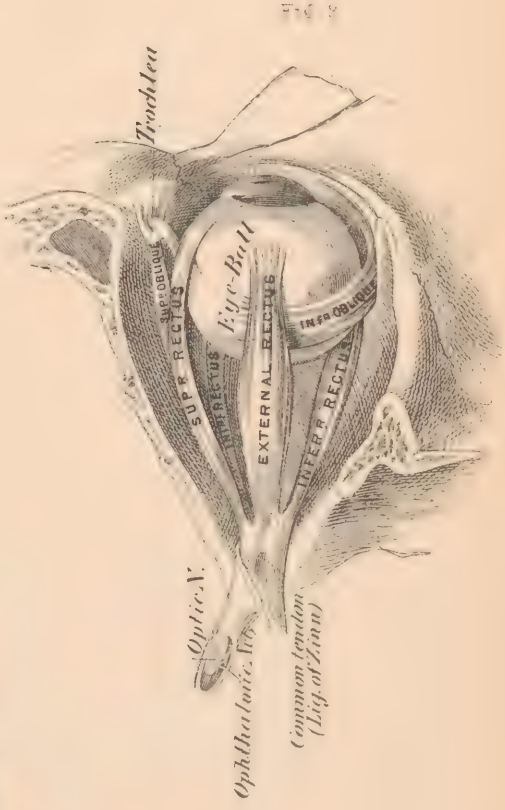
[1] R. L. Howard, N. Y. Journ. of Medicine, 1848, 177.
[2] Trans. Path. Soc. London, ii. 276.

EXPLANATION OF PLATE XLIV.

Fig. 1. The pterygoid and the buccinator muscles.
Fig. 2. The muscles of the neck.
Fig. 3. The superficial muscles about the eyeball.







J. Sinclair & Son Lith.

and by the skin. It is overlapped slightly from behind by the parotid gland, and crossed by the parotid duct and filaments of the facial nerve. Below it are the ramus of the lower jaw and the terminal portion of the tendon of the Temporal muscle, while in front lies the Buccinator, from which the Masseter is separated by a mass of delicate fat.

Use.—The Masseter elevates the lower jaw, and draws it slightly forward.

Artery.—The muscle is supplied by the masseteric artery, a branch of the internal maxillary.

Nerve.—The muscle receives a branch of the facial nerve at the sigmoid notch.

THE TEMPORAL.

The Temporal muscle arises by fleshy fibres from the entire surface of the temporal fossa (excepting that portion defined by the orbital septum) and from the upper third of the temporal aponeurosis. The latter structure is a beautiful glistening layer of fibres extending from the borders of the temporal fossa to the zygomatic arch. It is thin and weak at its origin, but increases in thickness as it descends, and divides near the zygoma into two leaflets. Between these is inserted a small quantity of compact adipose tissue. The Temporal muscle is composed of two portions—a superficial, thin and delicate, which arises from the aponeurosis; and a deep, which arises from the floor of the fossa. The fibres of the superficial are continuous above with the deep fibres, but below they are gradually lost in the deep layer of the Masseter muscle. The fibres of the deep portion, which compose the great bulk of the muscle, assume a position more vertical before than behind, where they are nearly horizontal. They gradually converge to a central tendon, which is inserted upon the coronoid process of the lower jaw, chiefly along its inner surface and anterior border.

Use.—To elevate the lower jaw.

Artery.—The muscle receives the temporal branches of the external carotid superficially, and the deep temporal branches of the internal maxillary artery from beneath.

Nerves.—Its nerves are branches of the facial and of the auriculo-temporal.

Relations.—Superficially to the Temporal muscle lie the integument, the temporal fascia, and the aponeurosis of the Occipito-Frontalis muscle as it affords origin to the auricular muscles. Beneath lie a portion of the temporal fossa, the External Pterygoid muscle, and the internal maxillary artery.

Remarks.—Pus may be guided from a deep temporal abscess to the coronoid process, and thence into the mouth, along the loose fat lying about the deeper portion of the muscle. By means of the great thickness of the substance of the muscle an extensive fracture of the skull at the temporal fossa may be disguised. The delicacy of the fibres arising from the temporal fossa, and the radiate manner in which they pass from the bone, explain why blood is not found in a clot between the muscle and the skull in instances of fracture of the latter through the temporal fossa, but is found incorporated with the muscle-fibres themselves. In the language of clinical writers the muscle is said to be "infiltrated" with blood. If the bleeding has been extensive, the deep portion of the muscle presents the appearance of a firm blood-clot, which, however, is limited outwardly by the position of the tendon.

THE INTERNAL PTERYGOID.

The Internal Pterygoid muscle has a tendinous origin from the pterygoid fossa. The fibres pass backward, downward, and outward, and are inserted upon the inner surface of the angle and the ascending ramus of the lower jaw. The muscle is of coarse structure, and is interspersed with stout bands of fibrous tissue.

The Internal Pterygoid muscle is an important factor in maintaining false anchylosis of the temporo-maxillary joint. After division of the anterior border of the Masseter muscle this condition may persist, but the anchylosis readily yields to division of the Internal Pterygoid.[1]

Use.—In connection with the Temporal and the Masseter the Internal Pterygoid raises the lower jaw. In connection with the External Pterygoid it draws the lower jaw forward.

Relations.—From the oblique position of the muscle the relations of its median portion are different from those of its outer portion. Thus the former is related to the Tensor Palati and Superior Constrictor of the pharynx; while to the lateral side of the latter portion lie the internal lateral ligament, the internal maxillary vessels, and the inferior dental artery and nerve.

THE EXTERNAL PTERYGOID.

The External Pterygoid muscle arises by two heads from the sphenoid bone: one from the under surface of the great wing at the pterygoid ridge; and one from the outer surface of the external plate of the pterygoid

[1] C. S. Tenner, Am. Journ. Med. Sci., July, 1854, 131.

process as well as from several adjacent areas upon the palate bone and the superior maxilla. The two heads unite to form a short stout belly, which passes outward and backward to be inserted into the depression on the anterior surface of the neck of the lower jaw, and into the interarticular cartilage of the temporo-maxillary articulation.

Use.—To draw the head of the lower jaw forward, and to assist in the act of grinding the food.

Nerve.—The muscle receives its motor filaments from the inferior maxillary division of the fifth nerve.

Variations.—The muscle may receive a slip from the Temporal. Longitudinal cleavage may be seen in each of the heads. This separation, when taking place in the sphenoidal head, gives rise to a fascicle which receives the name of the Pterygoideus Proprius.

Relations.—The internal maxillary artery lies at first to the outer side of the muscle, and afterward passes inward between the two heads. The temporal and masseteric branches of the fifth nerve cross it near its origin, and the buccal nerve passes between the heads.

II. THE MUSCLES OF THE NECK.

The muscles of the neck embrace the following:—

The Muscles of the Supra-Hyoid Space.
The Muscles of the Pharynx and the Soft Palate.
The Platysma Myoides.
The Sterno-Cleido-Mastoideus.
The Depressors of the Hyoid Bone.
The Deep Lateral and the Prevertebral Muscles.

The Muscles of the Supra-Hyoid Space (fig. 3, Plate XLIII.; fig. 2, Plate XLIV.; fig. 1, Plate XLV.).

The muscles of the space between the lower jaw and the hyoid bone (supra-hyoid space) include the following:—

The Digastric.
The Stylo-Hyoid.
The Mylo-Hyoid.
The Genio Hyoid.
The Genio-Glossus.
The Hyo-Glossus.
The Stylo-Glossus.

THE DIGASTRIC MUSCLE.

The Digastric muscle arises from the digastric groove of the temporal bone, and is inserted into the digastric fossa of the lower jaw, near the symphysis. As the name expresses, it has two bellies. The *posterior belly* is the longer and narrower of the two. The *anterior belly* is broad, and its fibres sometimes decussate with those of the muscle of the opposite side. The tendon uniting the bellies is held down to the hyoid bone by a firm loop of fibrous tissue, so that the muscle is more or less V-shaped. Commonly the Stylo-Hyoid muscle is perforated by this tendon.

Use.—The Digastric muscle depresses the lower jaw, and, when this bone is firmly fixed, elevates the hyoid bone.

Nerve.—The posterior belly is supplied by the facial, and the anterior by the mylo-hyoid branch of the inferior dental nerve.

Variations.—The entire muscle may undergo cleavage, or the posterior belly be alone divided. Accessions may be secured to the posterior belly from the styloid process, the angle of the jaw, or the Splenius. The intersection may be absent, and the muscle inserted on the side of the horizontal ramus of the lower jaw. Slips may pass from the anterior belly to the hyoid bone. The tendon may fail to pierce the Stylo-Hyoid muscle.

Relations.—The anterior belly is more superficial than the posterior. Above it lies the Platysma; below it, the Mylo-Hyoid muscle and the submental artery are found. The posterior belly has above it the anterior border of the Sterno-Cleido-Mastoideus muscle, and a lobule of the parotid gland. Below it lie the transverse process of the atlas, the internal jugular vein, the internal carotid artery, the second cervical nerve, the external carotid artery, and the origins of the facial and the lingual arteries.—The region of the intermediate tendon is overlaid by the Stylo-Hyoid muscle in part, and by the submaxillary gland. A little below the tendon lies the hypoglossal nerve.

THE STYLO-HYOID.

The Stylo-Hyoid muscle arises from the outer surface of the styloid process, between its middle and base. It is a slender muscle, and passes downward and inward to be inserted on the hyoid bone at the junction of the great cornu and the body. As a rule it is pierced for the transit of the tendon of the Digastric muscle.

Use.—To elevate the hyoid bone.

Nerve.—It is supplied by the facial nerve.

Variations.—Among the numerous variations of this muscle may be noted the following: Cleavage throughout—rarely three separate muscles may exist.—It may vary in its place of origin from the styloid process. It may be fused with the Omo-Hyoid at the hyoid bone. It may not be perforated by the Digastric. It may send slips to the lower jaw or Genio-Glossus. It may be inserted entirely into the lesser horn.

Relations.—These are essentially the same as those of the posterior belly of the Digastric.

THE MYLO-HYOID.

The Mylo-Hyoid muscle arises from the mylo-hyoid ridge of the lower jaw. Its fibres are, strictly speaking, entitled to the name only upon the outer margin of the muscle, since here alone are they inserted into the hyoid bone. The remaining fibres are more oblique in position, become successively shorter from below upward, and are inserted into a median raphé. This raphé, at all times indistinct, is often incomplete or absent when the division between the right and left muscle is destroyed.

Use.—The Mylo-Hyoid muscle forms the muscular floor of the mouth. It assists in raising the hyoid bone and drawing it forward. It also depresses the lower jaw.

Relations.—The Mylo-Hyoid muscle is at once the floor of the mouth and, at least in part, the roof of the neck. It lies superficially to the Genio-Hyoid muscle; has the anterior belly of the Digastric and the submental artery superficial to it; and permits the duct of the submaxillary salivary gland to effect entrance beyond its outer border. Upon the deep or oral surface lie the lingual nerve, the sublingual gland, and the mucous membrane of the alveo-lingual groove.

Variations.—It may be fused with the Digastric, or be absent when the last-named muscle takes its place. It may be continued by a few slips with one or more of the depressors of the hyoid bone. It may be perforated and dissected by the lobules or duct of the submaxillary salivary gland.

THE GENIO-HYOID.

The Genio-Hyoid muscle arises from the inferior genial tubercle of the lower jaw, and passes downward to be inserted into the anterior surface of the body of the hyoid bone.

Use.—With other muscles of its group to depress the lower jaw and to elevate the hyoid bone.

Nerve.—The Genio-Hyoid is supplied by a branch of the hypoglossal nerve.

Variations.—The muscle may undergo complete cleavage, or fuse with the corresponding muscle of the opposite side. Slight variations are met with in the extent of the mandibular and hyoidean attachments.

Relations.—Above is the Mylo-Hyoid. Below are the Hyo-Glossus in part, and the Genio-Glossus.

THE GENIO GLOSSUS.

The Genio-Glossus muscle arises at the symphysis of the lower jaw from the upper portion of the genial tubercle. It radiates through the tongue from before backward, constituting the bulk of the structure of this organ.

Under the erroneous impression that this muscle secures an important origin from the body of the hyoid bone, it is frequently described under the name Genio-Hyo-Glossus.

Use.—To draw the tongue forward.

Nerve.—It is supplied by the hypoglossal nerve.

Some of the fibres of the Genio-Glossus extend from the tongue to the anterior surface of the epiglottis. Some of the fibres of the Stylo-Pharyngeus (through the pharyngo-epiglottic ligament) run to the epiglottis. An anomaly of movement of the epiglottis has been described consequent upon paralysis of the left recurrent nerve from pleuritic effusion.[1]

THE LINGUALIS.

The Lingualis muscle lies in the substance of the tongue. It is a longitudinal fasiculus extending from the tip to the base. Some of its fibres can be traced into the Stylo-Glossus and the Hyo Glossus muscles.

THE HYO-GLOSSUS.

The Hyo-Glossus muscle is a thin, quadrate muscle, arising from the upper border of the body of the hyoid bone, the lateral border of the great cornu, and the lesser cornu. It passes upward and slightly forward to be inserted into the posterior lateral border of the tongue.

Use.—To aid in depressing the tongue.

Nerve.—The muscle receives a branch of the hypoglossal nerve.

Relations.—Above the muscle lie the Stylo-Hyoid, the Digastric, and the Mylo-Hyoid muscles, and part of the submaxillary gland. It is crossed by the hypoglossal nerve, and is pierced by Wharton's duct. The muscle rests upon the Genio-Glossus and the origin of the Middle Constrictor. Lying conspicuously beneath it is the lingual artery, and higher up is the glosso-pharyngeal nerve.

Variations.—It may be composed of a number of separate bundles. It may receive a slip from the Thyro-Hyoid.

THE STYLO GLOSSUS.

The Stylo-Glossus muscle arises from the tip of the styloid process. It passes downward and forward, and is inserted into the side and base of the tongue—some of its fibres crossing those of the Hyo-Glossus.

Use.—To aid in the retraction and elevation of the tongue.

Variations.—It may be absent. Its origin may secure accessions from the Internal Pterygoid, the angle of the lower jaw, the stylo-maxillary ligament, the tympanic portion of the temporal bone, or even from the cartilaginous external auditory meatus. Slips may pass to the pharynx.

[1] Schröeter, quoted in Boston Med. and Surg. Journ., April 8, 1875, 411.

The Muscles of the Pharynx and the Soft Palate.

These embrace—

The Superior Constrictor.
The Middle Constrictor.
The Inferior Constrictor.
The Stylo-Pharyngeus.
The Palato-Glossus.
The Palato-Pharyngeus.
The Tensor Palati.
The Levator Palati.
The Azygos Uvulæ.

THE SUPERIOR CONSTRICTOR.

The Superior Constrictor arises from the lower portion of the internal pterygoid plate, the pterygo-maxillary ligament, the mylo-hyoid ridge of the lower jaw, and the side of the tongue. The fibres from this extensive and varied origin pass directly backward, and are inserted on the posterior wall of the pharynx from the level of the angles of the lower jaw to the occipital bone; a few fascicles being received upon the pharyngeal spine and the aponeurosis attached to the basilar process of the occipital bone. Some of the fascicles are continuous with the Buccinator, and others with the Genio-Glossus.

The upper margin of the muscle is concave, and resembles the festooned border of a curtain held up at two points: viz., the pterygoid process in front, and the pharyngeal aponeurosis behind. The space intervening between the upper border and the base of the skull is occupied by the aponeurosis just named. The remaining fibres are nearly transverse. The lower border of the muscle is lost in the wall of the pharynx, and is, in part, overlapped by the more oblique fibres of the Middle Constrictor.

Use.—The pterygoid fibres, fixed as they are at their ends, convert, during contraction, the curved upper border into a straight one, and exert lateral pressure against the side of the naso-pharynx. Neither these, the buccal, nor the mandibular fibres can have a constricting action. The mandibular fibres can draw the posterior wall of the pharynx forward. The glossal fibres assist the Middle Constrictor.

Variations.—The several portions of the muscle may be distinct. Under the head of the Azygos Pharyngis, Meckel describes a small slip arising from the pharyngeal spine and becoming lost on the median line of the posterior pharyngeal wall.

Relations.—Lying to the outer side of the muscle are the internal carotid artery, the pneumogastric, the glosso-pharyngeal, and the spinal accessory nerves. Adjacent to the inner side are the Eustachian fossa and the origin of the Levator Palati muscle.

THE MIDDLE CONSTRICTOR.

The Middle Constrictor muscle (Plate XLV. fig. 2) arises from the greater and the lesser cornu of the hyoid bone. The fibres of the several portions pass upward and backward, directly backward, and backward and downward, and are inserted on the median line at the posterior wall of the pharynx from a short distance below the level of the hyoid bone to a point near the occipital bone. The upper fibres overlap the Superior Constrictor, in part, as the lower fibres in turn overlap the Inferior Constrictor.

Use.—To assist in elevating the hyoid bone; to adduct the cornu of the hyoid bone, and to draw forward the posterior pharyngeal wall. The hyoid bone is elevated by the Stylo-Hyoid muscle at the completion of the movement just named, and the fibres become of necessity less oblique than when the muscle is at rest.

Variations.—The slips from the lesser cornu may be distinct from those arising from the greater. Fibres may arise from the stylo-hyoid ligament, as well as from the body of the hyoid bone and the thyro-hyoid ligament. Fibres of continuity with the Genio-Glossus are here noted as in the case of the Superior Constrictor. The upper fibres may reach the occipital bone.

Relations.—Between the Superior and Middle Constrictors, at the side of the pharynx, the Stylo-Pharyngeus muscle passes. The superior laryngeal nerve lies between the Middle and Inferior Constrictor on its way to the thyro-hyoid membrane.

THE INFERIOR CONSTRICTOR.

The Inferior Constrictor muscle (Plate XLV. fig. 2), the shortest of the three, arises from the side of the thyroid cartilage, at the oblique lateral ridge, at the cricoid cartilage, and from a tendinous arch between these two points; the fibres pass upward and backward to be inserted on the median line of the pharynx for over one-half its length. The lower fibres are shortest, and merge gradually into the circular fibres of the œsophagus.

Use.—To constrict the lower part of the pharynx, and to serve as a protection to the laryngeal aperture. As such it may be seen in the living subject acting independently of the other muscles of its set. It assists in the propulsion of the bolus of food. In young subjects it may have some power in adducting

the halves of the thyroid cartilage, and thus lessening the transverse diameters of the larynx.

Variations.—Slips may be received from the Thyro-Hyoid, the Crico-Thyroid, and the Sterno-Thyroid muscles. The muscle may receive a few fascicles directly from the trachea.

The pharynx, in addition to the muscles named, is strengthened by submucous longitudinal fibres, and by the fibres of insertion of the Stylo-Pharyngeus, the Palato-Pharyngeus, and other fascicles passing from the cartilage at the orifice of the Eustachian tube.

THE STYLO-PHARYNGEUS.

The Stylo-Pharyngeus is a slender muscle arising from the styloid process and inserted into the side of the pharynx between the Middle and the Inferior Constrictor.

Use.—It aids the Stylo-Hyoid muscle in elevating the pharynx.

Nerve.—This muscle is supplied by a branch of the glosso-pharyngeal nerve.

Relations.—Beneath the muscle lies the ascending pharyngeal artery. Above it lies the submaxillary salivary gland.

THE PALATO-GLOSSUS

arises from the anterior surface of the soft palate at the base of the uvula, and passes downward along the lateral wall of the pharynx to be inserted into the side of the base of the tongue. It is of a dusky-red color in health, and the fold of mucous membrane over it forms the palato-glossal fold or the "anterior half arch."

Use.—To draw the palate slightly downward and forward. It also aids in keeping the tonsil in position. Both muscles acting together depress the soft palate and draw it forward, and, in the act of sucking, constrict the nipple.

Each muscle may be looked upon as a sphincter on a deeper plane than the lips, but like it in nature, and it is supplied by the same motor nerve, viz., the facial. It is also a noteworthy fact that the plane of the two muscles limits the region of involution of the epiblast—so that the palato-glossal muscles are less splanchnic than the pharyngeal muscles proper.

THE PALATO-PHARYNGEUS

arises from the soft palate at the base of the uvula behind the Palato-Glossus. It passes downward to be inserted into the lower part of the side of the pharynx. Some of its fibres can be occasionally traced to the thyroid cartilage. The fold of mucous membrane over it constitutes the palato-pharyngeal fold or "posterior half arch."

Use.—To keep the soft palate in position during respiration. In deglutition, to elevate the pharynx; in order to make this action efficient, the palate must be elevated. The muscles then secure fixed points at their palatal connections, and assume a nearly vertical position. C. J. P. Yule[1] concludes, from observations on his own person, that the Palato-Pharyngeus is the chief factor in opening the Eustachian tube.

THE TENSOR PALATI.

This muscle arises from the sphenoid bone and the Eustachian tube. From the former it arises from the scaphoid fossa, and from the angular or spinous process. From the latter it arises from the hook cartilage. The fibres of both surfaces are at their origin contiguous, and form a small muscle which descends vertically to the end of the pterygoid process as far as the hamular process, around which its tendon turns to be distributed radially upon the aponeurosis of the soft palate. Some of its fibress are inserted upon the palatal bone.

Use.—This muscle, as its name expresses, was supposed to make the soft palate tense. This view is now no longer held. The muscle probably dilates the orifice of the Eustachian tube.

THE LEVATOR PALATI

arises from the end of the petrous portion of the temporal bone, and from the under surface of the Eustachian tube near its pharyngeal orifice. It receives some fibres from the cartilage of the tube. It is inserted into the soft palate near the uvula. The direction of the muscle is obliquely downward and inward.

Use.—With reference to the soft palate: The muscle elevates the soft palate and makes it tense, since the right and left muscles act synchronously. With reference to the Eustachian tube: The shortening of the body of the muscle, together with the increase of its diameter, has a tendency to close the orifice of the tube by elevating the lower border. The action of the Levator Palati can be readily studied in the living subject by the rhinal mirror. By such aid the course of the muscle, even when at rest, can be seen corresponding to an oblique fold of mucous membrane which may receive the name of the salpingo-palatal fold.

[1] Journ. of Anat. and Phys., viii. 1873; also Author's memoir on Soft Palate, Trans. Amer. Med. Assoc. 1872, 537.

The Levator Palati receives much attention in the improved operation of staphylorraphy. Fergusson, having noticed the influence of this muscle in widening the cleft in the soft palate, essays its division before uniting the freshened edges. This procedure is now an established antecedent to the operation.

The actions of the Levator Palati and Tensor Palati muscles have been the subject of controversy. Valsalva, as long ago as 1742, described both the above muscles as dilators of the tube. Toynbee,[1] in 1853, revived Valsalva's account; and later Rüdinger and other German writers have accepted this as the true action. Respecting the Tensor Palati, Henle[2] is inclined to adopt the view that the muscle closes the orifice; while, as seen in another part of the same volume (p. 117), he doubts the ability of the muscle to close the tube. His views upon the function of the Levator Palati agree with those expressed in the text.

The author has long taught that the contraction of the Levator Palati narrows the pharyngeal orifice of the tube. This action can be readily seen in the living subject by the aid of reflected light. Cleland[3] studied the action of the same muscles in a man who had lost the soft palate by ulceration. He doubts the efficacy of the Tensor Palati in dilating the tube, while he assigns to the Levator Palati its proper function, in assisting to narrow the orifice. That the Eustachian tube (*q. v.*) is always patulous in health, and that, while certain muscles tend to narrow its lumen, none can obliterate it, seem to be fair deductions from its nature.

THE AZYGOS UVULÆ.

The Azygos Uvulæ muscle is a slender slip arising from the posterior palatal spine and inserted into the free extremity of the uvula.

Use.—To contract the uvula.

The Salpingo-Pharyngeus is a small muscular slip passing from the cartilage of the Eustachian tube to the pharynx.

Use.—To assist the action of the Palato-Pharyngeus.

[1] Trans. Phil. Soc. Lond., 1853.

[2] Anatomie, ii. 755.

[3] Journ. of Anat. and Phys., iii. 1869, 97.

The Platysma Myoides.

The Platysma Myoides muscle is a thin quadrangular sheet arising from the subcutaneous connective tissue and from the fascia over the Pectoral, Deltoid, and Trapezius muscles. It passes upward and forward over the clavicle and the acromion to the lateral region of the neck to be inserted into the horizontal portion of the lower jaw in advance of the Masseter muscle. Some of the fibres pass further upward to be lost upon the face.

Use.—To elevate the skin over the chest, and then, being fixed, to depress the lower jaw. It doubtless also aids in making tense the superficial cervical fascia.

Remarks.—The two muscles tend to decussate at a point below the symphysis of the jaw.—The facial fibres, when inserted at the angle of the mouth, constitute the Risorius muscle.—Welcker[1] describes the muscle as arising from the lower jaw, and as being inserted directly into the skin over the front of the sternum and the lower part of the neck. He ascribes to it a function of elevating the skin over these parts.

Variations.—The acceptance of the Platysma as a rudiment of the Panniculus Carnosus, or the great subcutaneous muscle of quadrupeds, yields a clue to the variations of the muscle in the human subject. To rare instances of defect in development may be added frequent errors of excess by which slips from the muscle pass to one or more of the muscles of expression, the thyroid cartilage, the mastoid process, or the costal cartilages. Detached fascicles can be sometimes traced to the axilla.

Relations.—Above the muscle is the integument. Beneath, at the supra-hyoid region, lies the facial artery. A little farther down lie the external jugular vein, its tributaries, and the ascending superficial branches of the cervical plexus. Above the clavicle lie the termination of the external jugular vein, and the descending superficial branches of the cervical plexus. Separated by the layer of the cervical fascia are the superficial cervical lymphatics and the Sterno-Cleido-Mastoideus muscle.

[1] Zeitschr. für Anat. und Entwickelungsgesch., i. 1876, 198, fig.

EXPLANATION OF PLATE XLV.

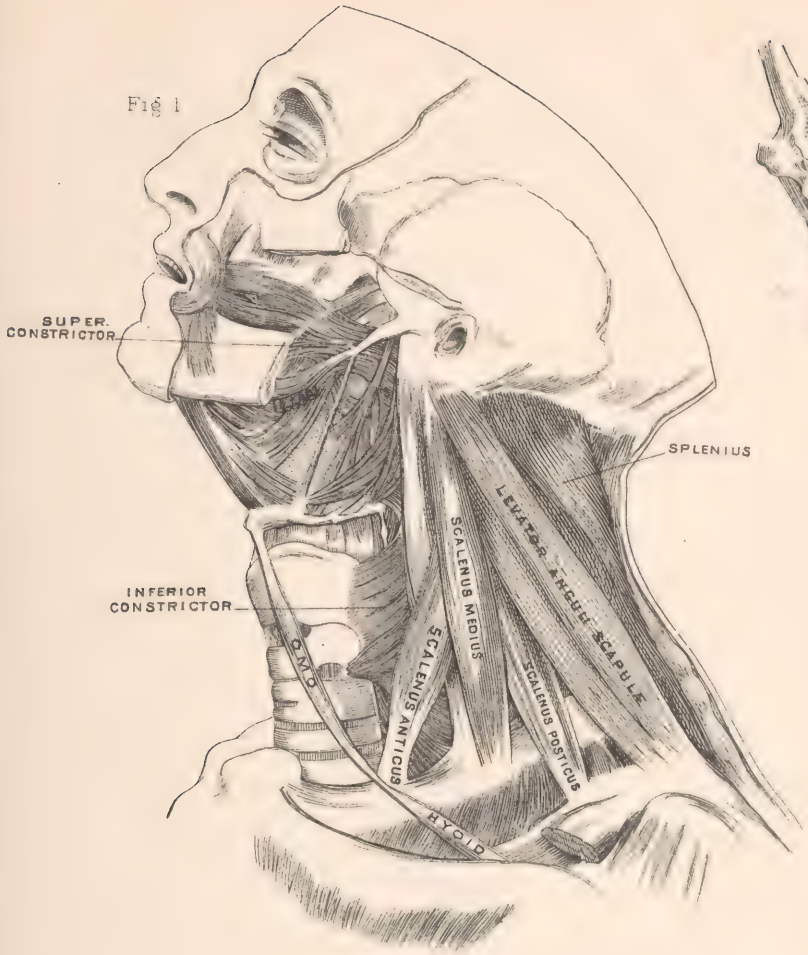
Fig. 1. The deep muscles of the neck, and the muscles of the pharynx in part.

Fig. 2. The muscles of the pharynx, seen from behind.

Fig. 3. The muscles of the neck, attached to the vertebræ.

PLATE XLV

Fig 1



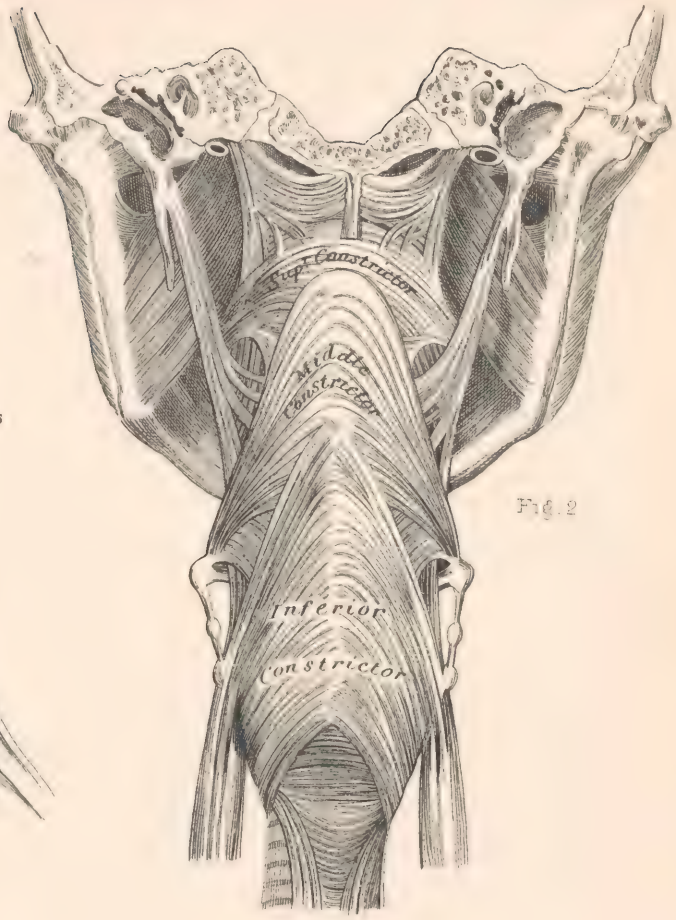
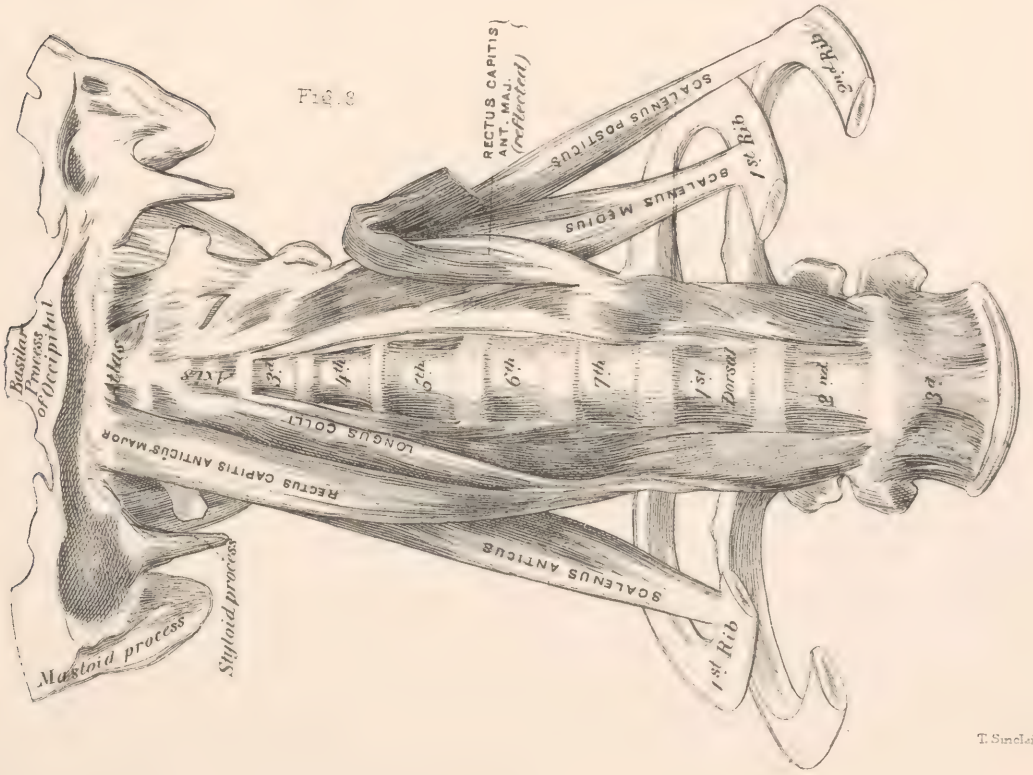


Fig. 2

Fig. 3



T. Sinclair & Son, Lith.

The Sterno-Cleido-Mastoideus.

The Sterno-Cleido-Mastoideus muscle arises by two heads: the one from the anterior border of the upper end of the sternum, the other from the sternal end of the clavicle. It passes upward and outward, forming a large sub-rounded belly to be inserted into the mastoid process. It is composed of two laminæ united at the anterior border.

Use.—To bring the head forward in the nodding position when both muscles act together, or to bring the head downward and to one side, and to rotate it when one muscle acts singly. Each muscle may assist in actions of the anterior and the posterior set of cervical muscles. The head being fixed, the muscle becomes an accessory muscle of respiration by assisting in elevating the thorax. It also serves to fix the clavicle.

Nerves.—The muscle is supplied by the cervical plexus and by the spinal accessory.

Relations.—To its outer side is the external jugular vein. The superficial branches of the cervical plexus of nerve escape at its outer border. The auricularis magnus and the superficial cervical nerves are conspicuous in crossing the muscle. At the upper posterior border the occipitalis minor nerve ascends to the occiput, while the sternal and clavicular branches are apt to cross the muscle obliquely on their way to the thorax. The spinal accessory nerve pierces the posterior border. Beneath the muscle lie the Splenius Capitis, the Omo-Hyoid muscle, the Digastric and Stylo-Hyoid muscles, and a portion of the Sterno-Hyoid and Sterno-Thyroid muscles. Over it is the Platysma Myoides muscle. It is intimately held to the superficial fascia and integument at its insertion. The anterior border overlies the parotid gland.

Variations.—The muscle may be separated into two distinct portions. The two heads are rarely fused. The sternal head may be duplicated. Slips may pass to the lower jaw (constant in the horse) and to the stylo-maxillary ligament. The sternal head may pass down on the sternum a variable distance. Gruber[1] identifies a fascicle which passes down the entire length of the sternum as belonging to this head. Slips of the same head may overlie the Pectoralis Major and the cartilages of the true ribs. A separate group of muscles placed between it and the muscles on the back of the neck are thought to be variations of the Sterno-Cleido-Mastoideus. Such are independent bundles from the occiput and the cervical vertebræ to the clavicle, or a slip from the cervical vertebræ to the acromion. These tend to fuse with the Trapezius and to be compensatory with the Levator Anguli Scapulæ.

[1] Mém. de l'Acad. des Sciences, St. Petersbourg, 1860, 3.

Remarks.—This muscle in contracting causes a pouch to form in the superficies of the neck at its lower part, between the trachea and the deep fascia. Erichsen[1] calls especial attention to this in describing tracheotomy. Instances have been known where the tracheal tube was thrust into this pouch, the operator believing that it was in the trachea.

Whenever the deep-seated lymphatics at the base of the neck become enlarged, the tumor is formed behind the posterior belly of the Omo-Hyoid muscle, is bound down by it and the fascia, continues for a length of time unchanged in appearance. At last it is protruded outwardly, pushing before it the Omo-Hyoid, by which the acromial margin of the Sterno-Mastoid is turned forward, and its clavicular portion pulled up on the side of the tumor and carried away from the sternal part. This position of the Sterno-Mastoid depends on its connection with the Omo-Hyoid. When, therefore, the Sterno-Mastoid is seen pulled over a tumor situated between that muscle and the Trapezius, the surgeon may be certain that it is deeper than the Omo-Hyoid.[2]

This muscle is sometimes ruptured in childbirth.[3]—It was found by Canton[4] exceedingly tense in luxation of the sternal end of the clavicle. There was no rupture of its fibres—a condition which, according to Nélaton, notably occurs in those cases in which the sternal end is inserted beneath the articulation itself.—Induration of a peculiar character is occasionally met with in this muscle in new-born children. It appears to be an obscure form of local swelling directly in the substance of the muscle.

The Depressors of the Hyoid Bone (fig. 2, Plate XLIV.; fig. 1, Plate XLV).

These include—

The Sterno-Hyoid.
The Sterno-Thyroid.
The Thyro-Hyoid.
The Omo Hyoid.

THE STERNO-HYOID.

The Sterno-Hyoid muscle arises from the posterior surface of the sternum near its free upper border. It passes upward as a ribbon-shaped mass, having straight fibres to be inserted into the body of the hyoid bone to the median side of the Omo-Hyoid muscle.

[1] Surgery, 916.
[2] Burns, Surg. Anat., 77.
[3] Wm. Smith, Trans. Clin. Soc., iv. 70.
[4] Lancet, Sept. 15, 1860, 264.

Use.—To depress the hyoid bone.

Relations.—This muscle is covered with the sternum below, and with the Platysma and the Sterno-Cleido-Mastoid above. Below lie the Sterno-Thyroid and the Thyro-Hyoid muscles, as well as a branch of the superior thyroid artery. To its inner border lies the muscle of the opposite side. These muscles, however, are not in contact, save at a small surface.

The origin of the Sterno-Hyoid muscle exhibits frequent Variations, which are due to its extension behind the sterno-clavicular articulation, or to the clavicle. The posterior surface may be marked by a transverse tendinous inscription.

THE STERNO-THYROID.

The Sterno-Thyroid muscle arises from the posterior surface of the sternum and the first rib, and passes upward to be inserted into the oblique line on the side of the thyroid cartilage. It is somewhat broader than the Sterno-Hyoid muscle, but resembles it in its general features.

Use.—To depress the thyroid cartilage, and indirectly the hyoid bone.

Relations.—Beneath the muscle, at its origin, often lies a branch of the superior thyroid artery. Below it are the trachea, the thyroid body, and the thyroid cartilage. Above it are the sternum, the Sterno-Hyoid, and the Sterno-Cleido-Mastoid muscle in part. To its inner side, near the sternum, it is in contact with the muscle of the opposite side in front of the trachea. The upper part of the muscle is firmly held in place by fascia; but the lower part, near the sternum, is surrounded by connective-tissue of loose texture. To the outer side is the internal jugular vein. According to Quain, slips may pass to the Thyro-Hyoid muscle or to the inferior constrictor of the pharynx. Like the Sterno-Hyoid, the Sterno-Thyroid is often marked by a transverse tendinous line.

THE THYRO-HYOID.

The Thyro-Hyoid muscle arises from the oblique line of the thyroid cartilage, and passes upward to be inserted into the hyoid bone at the body and at the greater cornu.

Use.—To raise the thyroid cartilage, or, when the thyroid is fixed, to depress the hyoid bone.

Relations.—Above, the muscle is covered by the Sterno-Hyoid and the Omo-Hyoid muscles. Below it are the thyroid cartilage and the thyro-hyoid membrane. Passing beneath it to effect entrance into the larynx through the thyro-hyoid membrane are the superior laryngeal nerve and artery.

Variation.—Gruber[1] describes a slip passing from the surface of the thyroid cartilage to the trachea.

[1] Bull. de l'Acad. Imp. St. Petersbourg, 1861, 154.

THE OMO-HYOID.

The Omo-Hyoid muscle arises from the upper border of the scapula, near the supra-scapular notch. It passes upward and forward, and is inserted into the hyoid bone at the lower border of the body. It is a thin slender muscle, and is remarkable for exhibiting a central tendon, which separates the muscle, more or less distinctly, into two bellies. The tendon is held in a loop of deep fascia, and lies behind the Sterno-Cleido-Mastoid muscle.

Relations.—Anterior belly: Above lies the Platysma. Beneath are the Sterno-Hyoid, and a branch of the superior thyroid artery and vein. Posterior belly: Above are the Trapezius, the Subclavius, the clavicle, and the Sterno-Cleido-Mastoid muscle. Beneath are the Scaleni, the brachial plexus in part, the sheath of the great vessels, the descending branch of the hypoglossal nerve, and the Sterno-Thyroid muscle. At its insertion the Omo-Hyoid lies to the outer side of the Sterno-Hyoid muscle.

Burns[1] narrates a case where destruction of the depressors of the hyoid bone by suppuration caused such pressure upon the trachea during inspiration as to interfere with respiration. The trachea, the innominate artery, and the thyroid branch of the lower thyroid artery were found to be covered merely by a thin pellicle of skin.

Variations.—The muscle may undergo cleavage throughout or in part. It may be absent, or one belly alone be present. It may fuse with the Sterno-Hyoid. It may receive an accession from the clavicle. The line of origin may be shifted forward to the coracoid process or to the first rib. An independent slip may extend from the hyoid bone to the clavicle.[2]

The Deep Lateral and the Prevertebral Muscles of the Neck.

These embrace the following:—

- The Deep Lateral.
  - Scalenus Anticus.
  - Scalenus Medius.
  - Scalenus Posticus.
- The Prevertebral.
  - Rectus Capitis Anticus Major.
  - Rectus Capitis Anticus Minor.
  - Rectus Capitis Lateralis.
  - Longus Colli.

THE SCALENI MUSCLES.

These extend from the cervical vertebræ to the first and second ribs. They are three in number: the Anterior, the Middle, and the Posterior.

[1] Surgical Anatomy, 36.

[2] Gruber, Bull. de l'Acad. St. Petersbourg, 1872, 158.

The Scalenus Anticus muscle arises from the anterior tubercles of the transverse processes of the cervical vertebræ from the third to the sixth. It passes downward to be inserted into the first rib at a tubercle in advance of the subclavian groove.

Relations.—The muscle lies to the outer side of the Longus Colli and the Rectus Capitis Anticus Major. To its outer side emerges the cervical plexus of nerves. Behind it lies the subclavian artery, while in front lies the subclavian vein. The muscle is crossed by the phrenic nerve obliquely from without inward, while the Omo-Hyoid crosses it from below upward and inward.

The muscle is sometimes pierced by the subclavian artery. In such an instance Albinus described the posterior fasciculus as the Scalenus Minimus.

The Scalenus Medius muscle arises from the posterior tubercles of the transverse processes of all the cervical vertebræ excepting the atlas. It passes downward to be inserted into the first rib at the upper border and the posterior surface.

Hyrtl gives the origin of this muscle from all the transverse processes.

Relations.—The Anterior Scalene lies in front of the Posterior Scalene, and the Levator Anguli Scapulæ behind it. Between the two Scalene muscles is a triangular space occupied by the subclavian artery and the brachial plexus of nerves.

The Scalenus Posticus muscle arises from the posterior tubercles of the transverse processes of the last three cervical vertebræ. It passes downward to be inserted into the outer surface of the second rib between its tubercle and the angle, directly in advance of the insertion of a digitation of the Serratus Magnus.

Variations.—The Scalene muscles are compensatory with one another; they may fuse with one another. They may range in origin along all the transverse processes of the cervical vertebræ, the seventh alone excepted. One may be absent.—The Scalenus Anticus may fuse with the Rectus Capitis Anticus Major. It may be pierced by the phrenic nerve.—The Scalenus Posticus may send a slip to the Levator Anguli Scapulæ. It may undergo longitudinal cleavage, and be inserted into the first, second, and third ribs.

Use.—To raise the ribs upon which they are inserted. Henle compares the Scalenus Anticus and Scalenus Medius to the intercostal muscles, since they are in contact with the pleura, assist in closing the superior thoracic aperture, and assist in protecting the chest wall at its upper part.—Slips of the Scalene group, apparently detached from one of the above-named muscles, have received the names of Scalenus Lateralis, Scalenus Minimus, and Scalenus Accessorius.

THE RECTUS CAPITIS ANTICUS MAJOR

arises from the anterior tubercles of the transverse processes of the cervical vertebræ from the third to the sixth. It ascends inclining slightly toward the median line, and is inserted upon the basilar process of the occipital bone.

Variations.—It may fuse with the Longus Colli, and in part with the Scalenus Anticus. Its slips of origin are variable in a range from the second to the fifth.

THE RECTUS CAPITIS ANTICUS MINOR

arises from the transverse process and anterior arch of the atlas. It passes upward and inward beneath the preceding, and is inserted into the basilar process.

Variations.—It may be absent, or undergo longitudinal cleavage. A fascicle may join the preceding muscle.

THE RECTUS CAPITIS LATERALIS

extends from the transverse process of the atlas to the jugular process of the occipital bone. It is homologous with the Intertransverse muscles of the vertebral column.

Uses.—The greater and the lesser Recti muscles incline the head forward and slightly rotate it. They antagonize the muscles on the back of the neck.

THE LONGUS COLLI.

The Longus Colli consists of three portions: a median, a superior, and an inferior oblique.

The median portion arises from the body of the axis, and passes downward in a nearly straight line to be inserted into the bodies of the third and fourth dorsal vertebræ.

The superior oblique portion arises from the tubercle of the atlas, and is inserted into the anterior tubercle of the transverse process of the third and fourth cervical vertebræ.

The inferior portion arises from the second and third dorsal vertebræ, and is inserted into the anterior tubercles of the transverse process of the sixth and seventh cervical vertebræ.

Use.—The Longus Colli bends the neck forward when the median fibres, or to one side when the lateral fibres contract. It may also slightly rotate the cervical vertebræ.

Variations.—The muscle may be thin or rudimentary. It may send fibres to the head of the first rib.

THE CERVICAL FASCIA.

The soft parts of the neck are held together by fascia and intermuscular septa, which present some peculiarities. At the back of the neck, and for the most part at the sides, the fleshy and fibrous elements are compactly adapted to one another and to the vertebræ. At the front the case is different: Here the lower jaw, the respiratory apparatus and its associated muscles, the Sterno-Cleido-Mastoideus muscle, the great vessels as well as the movable boundaries of the superior thoracic aperture, all permit considerable latitude of motion. The disposition of the fascia to facilitate this motion, and at the same time to afford protection to the vessels and nerves of the neck, is sufficiently striking to demand a separate section for its consideration.

The fascia of the front of the neck forms many layers, of which may be mentioned the following:—

(1) A superficial layer in which is incorporated the Platysma Myoides. It is continuous with the superficial fascia on the chest and with the fascia of the superior extremity.

(2) Two layers, in the space between which is inclosed the Sterno-Cleido-Mastoideus muscle. These layers are for the most part thin, and allow the muscular fibres to be seen through them. Above, near the angle of the jaw, they become thicker and are more adherent to the muscle than elsewhere. On either side of the muscle the two inclosing layers unite: The inner passes inward to cover in the great vessels, and the Sterno-Hyoid, the Sterno-Thyroid, and the anterior belly of the Omo Hyoid muscles. The outer lies over the origin of the brachial plexus and over the origin of the Scalene muscles; it contains some adipose tissue, small veins, and lymphatic glands. At the anterior margin of the Trapezius muscle it again divides to inclose this muscle, and is lost on the back.

(3) The layer inclosing the lower belly of the Omo-Hyoid (Omo-Hyoid fascia). This is a rather stout fascia which passes over the muscle down to the first rib. Upon this layer the intermediate tendon of the Omo-Hyoid is secured.

(4) The sheath of the great vessels and the pneumogastric nerve. This is somewhat distinct from the preceding, as is the connective tissue in front of the cervical vertebræ.

(5) The fascia associated with the depressors of the hyoid apparatus. This can be traced downward into the thorax, and thence as far as the pericardium (cervico-pericardial aponeurosis of Godman), and exerts, it is thought, slight influence in suspending the heart.

(6) The layers inclosing a space about the position of the submaxillary salivary gland, the associated lymphatic gland, and stretching between the intermediate tendons of the Digastric muscles. The lateral border of the inter-digastric layer coincides with the level of the Sterno-Cleido-Mastoid muscle.

This division of the fascia is sometimes called the *supra-hyoid aponeurosis.* Its position corresponds to that of a sheet of muscular fibre belonging to the Digastric muscles in some of the lower animals. In the variations of the Digastric in man, slips of contribution are described passing over this aponeurosis to the Mylo-Hyoid muscle.

Remarks.—The medical relations of the cervical fascia are numerous and important. The following comments, with cases, will doubtless prove of interest.

Abscess above or in the superficial layer has no disposition to burrow, no matter how extensive a surface it may occupy.—In the space above the clavicles, between the Sterno-Cleido-Mastoid muscles, abscess sometimes forms at a point midway between the prevertebral and the superficial localities. This space is occupied with fat, with the common trunk of the anterior jugular and median jugular veins, and occasionally with a small lymphatic gland. It communicates with a recess behind the Sterno-Cleido-Mastoid muscle carrying the transverse cervical vein. The pus in this space inclines by gravity to extend behind the sternum.—The case is far different in an abscess situate between the fascia inclosing the Sterno-Cleido-Mastoid and that inclosing the Omo-Hyoid muscle. The pus here is inclined to follow the plane of the posterior belly of the Omo-Hyoid muscle to the first rib, and thence to the axilla.—Should an abscess occupy the space between the Omo-Hyoid fascia and that of the great vessels of the neck (often described as the space between the second and the third layers), the pus is inclined to pass downward along the course of the jugular vein, or inward about the trachea or œsophagus, or somewhat laterally toward the back of the neck.

Abscess in the prevertebral space is either formed about the deep cervical lymphatic glands found in that position, or gravitates thence from behind the pharynx. Should there be no point of softening to serve as a guide, the incision for relief should be made parallel to the outer border of the Sterno-Cleido-Mastoid muscle. The great vessels are liable to be displaced by such a collection to a remarkable degree. A careful dissection should be made, and the director

or probe should be used to separate the matted tissues below the well-defined layers of fascia.

In a case of fracture of the right clavicle, under the care of Erichsen,[1] a red and œdematous swelling, which was noticed at the base of the neck, filled up the supra-clavicular depression and overlapped the prominence of the bone. Such involvement of the connective tissue of the neck from injuries to the clavicle is rare.

J. W. Cusack[2] describes a tumor which occupied the supra-hyoid space, and extended thence below to the thyroid cartilage and above to the left ear. The mass had displaced the submaxillary gland upon the jaw, and pushed the Digastric and Stylo-Hyoid muscles upward, and the external carotid artery outward. It also involved the greater cornu of the hyoid bone and the hypoglossal nerve. In its removal the external carotid artery was ligated, and the hypoglossal nerve cut through. The patient recovered with atrophy and paralysis of the corresponding side of the tongue.

Abscess of the upper part of the neck, namely, from the hyoid bone upward, has an inclination to pass directly backward and involve the base of the tongue and the region of the epiglottis.[3] Two cases are given by G. Buck,[4] in which the corresponding half of the epiglottis, together with the aryteno-epiglottidean fold, became involved from such an abscess. In one of these patients death ensued from œdema of the glottis.

Mohrenheim's fossa is the name given to the depression above the clavicle to the outer side of the Sterno-Cleido-Mastoideus muscle. The subclavian artery can be compressed against the first rib at this point. Incision or the exploration of sinuses, in this region, should be made with caution. The numerous small veins bleed freely, owing probably to their cut ends being made patulous by their connection with the cervical fascia.

III. THE MUSCLES OF THE TRUNK.

The muscles of the trunk[5] embrace—

The Muscles of the Back.
The Muscles of the Thorax.
The Diaphragm.
The Muscles of the Abdomen.

The Muscles of the Back.

The best arrangement of the muscles of the back is that based upon their functions.

In the first group is embraced the great Erector Spinæ muscle, including in this term the Sacro-Lumbalis, Longissimus Dorsi, Spinalis Dorsi, Transversalis Cervicis, Musculus Accessorius, and Ascendens Cervicis.

In the second group are the muscles arising from the vertebræ and inserted into the ribs. These embrace the Levatores Costarum, the Serratus Posticus Superior, and the Serratus Posticus Inferior.[1]

In the third group may be placed the muscles passing between the vertebræ, and those passing between the vertebræ and the skull. Four kinds of motion are here recognized: the backward, forward, lateral, and rotatory. The muscles effecting the *backward* movement (or extension) are the Splenius Colli, Interspinales, Rectus Capitis Posticus Minor, and Rectus Capitis Posticus Major; those effecting the *forward* movement (flexion) are the Longus Colli, Psoas,[2] Rectus Capitis Anticus Minor, Rectus Capitis Anticus Major; those effecting the *lateral* movement are the Intertransversales, the Rectus Capitis Lateralis, the Trachelo-Mastoid; those effecting the *rotatory* movement are the Rotatores Spinæ, Multifidus Spinæ, Semispinalis, Obliquus Capitis Inferior, Obliquus Capitis Superior, Complexus, and Splenius Capitis.[3]

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[1] Lancet, Dec. 24, 1870.

[2] Dublin Hospital Reports, i., 1818, 205.

[3] R. W. Smith, Dub. Quart. Journ., 1846, i. 553.

[4] N. Y. Med. Journ., 1866, ii. 36.

[5] In a classification of muscles based upon physiological considerations, the muscles of the trunk do not include those of the perineum, some of which belong to the alimentary canal, and others to the genito-urinary apparatus. It will nevertheless be seen that the muscles of the perineum lie within the trunk, which is defined as that portion of the body which remains when the head, neck, and limbs are removed—the *torso* of the artist.

[1] The Scaleni have arbitrarily been considered among the muscles of the neck. Their true position is in the second group as above indicated. In like manner the anterior portion of the Quadratus Lumborum may be placed in this group.

[2] Conventionally included in the muscles of the lower extremity.

[3] This classification is essentially that of G. Hermann Meyers (Lehrbuch der Anatomie des Menschen, Leipzig, 1855–73), and Theile (Müller's Archiv. für Anat., 1839, p. 102, fig.), and, as far as the first group is embraced therein, that of Joseph Leidy (An Elementary Treatise of Human Anatomy, Philadelphia, 1861).

Anatomists have not agreed upon a uniform plan for arranging the muscles of the back. The English writers divide them into layers—a purely artificial classification, and designed only to facilitate the task of their dissection. Five layers are by them named as follows:—

The *First Layer* is composed of the
Trapezius. Latissimus Dorsi.

The *Second Layer* of the
Levator Anguli Scapulæ.
Rhomboideus Major. Rhomboideus Minor.

The First Group of muscles includes the Erector Spinæ and its subdivisions.

THE ERECTOR SPINÆ.

The Erector Spinæ consists of two portions—a median and a lateral. The median portion is called the Longissimus Dorsi, and the lateral the Sacro-Lumbalis.

The Longissimus Dorsi arises from the spines of the sacrum and the spines of the lumbar vertebræ, as well as from the lower and back part of the sacrum. It is inserted by serrate slips into the posterior ends of the ribs (excepting the first and last) near their tubercles, and into the transverse processes of the lumbar vertebræ.

The Sacro-Lumbalis (more properly called the Ileo-Costalis) arises by fleshy fibres from the outer fifth of the crest of the ilium, and is inserted by serrate slips into the inferior border of each rib, near the angle.

The subdivisions of the Erector Spinæ embrace—

The Spinalis Dorsi.
The Transversalis Cervicis.
The Musculus Accessorius.
The Ascendens Cervicis.

The Spinalis Dorsi is a long narrow muscle sometimes described as distinct from the Longissimus. It extends from the spines of the first two lumbar and the two lowest dorsal vertebræ, and is inserted into from four to eight of the higher dorsal spines.

Under the name of the Transversalis Cervicis the Longissimus sends a cervical slip from the transverse processes of the fourth and fifth dorsal vertebræ to the posterior tubercle of the transverse process of each of the cervical vertebræ excepting the first and the seventh. The Transversalis Cervicis may secure slips of origin from the two lower cervical vertebræ.

The Musculus Accessorius and Ascendens Cervicis are accessory cervical slips analogous to the Transversalis Cervicis. They pass upward from the upper five or six ribs to the transverse processes of the third or the fourth cervical vertebra.

The Longissimus Dorsi is apparently united by fibrous tissue to the crest of the ilium. It effects a slight union with the lumbar fascia.

When the Erector Spinæ is removed, the Posterior Inferior Serratus, and the deep layer of the aponeurosis are exposed. The latter is known as *the posterior layer of the lumbar fascia*. It extends from the transverse processes of the lumbar vertebræ between the last rib and the crest of the ilium. It affords fibres of attachment to the Longissimus Dorsi, and covers in the Quadratus Lumborum muscle.

The *anterior layer of the lumbar fascia* is best seen from within the abdomen. It is in relation with the prevertebral region. It serves as the fascial covering of the anterior surface of the Quadratus Lumborum, and is continuous above with the *ligamenta arcuata* of the Diaphragm.

Use.—When both act, to extend the spine. When one muscle acts separately, particularly when the Longissimus Dorsi contracts, to draw the vertebral column to one side.

Variation.—The Erector Spinæ is subject to slight and unimportant variations.

The Vertebral Aponeuroses.—The Vertebral Aponeuroses is the name given to a system of membranous layers attached to the vertebræ and serving to define the relations between the muscles of the back. When the skin of the lumbar region is removed, the *superficial layer* of the aponeurosis or dorso-lumbar fascia is exposed. This layer is a beautiful glistening membrane occupying the interval between the sacral and lumbar spines and the crest of

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The *Third Layer* of the
Serratus Posticus Superior.
Serratus Posticus Inferior.
Splenius Capitis.
Splenius Colli.

The *Fourth Layer* of the
Erector Spinæ and its subdivisions

The *Fifth Layer* of the
Semispinalis Dorsi.
Semispinalis Colli.
Multifidus Spinæ.
Rotatores Spinæ (Supra Spinales).
Interspinales.
Extensor Coccygis.
Intertransversales.
Rectus Posticus Major.
Rectus Posticus Minor.
Obliquus Superior.
Obliquus Inferior.

Hyrtl arranges the muscles into three groups according to their shapes: the Broad, the Long, and the Short.

The *Broad Muscles* embrace the
Trapezius.
Latissimus Dorsi.
Rhomboideus.
Levator Anguli Scapulæ.
Serratus Posticus Superior.
Serratus Posticus Inferior.
Splenius.

The *Long Muscles* embrace the
Erector Spinæ.
Complexus.
Spinalis Dorsi.
Semispinalis Dorsi (Spinalis Cervicis, Semispinalis Cervicis).

The *Short Muscles* embrace the
Multifidus Spinæ.
Interspinales.
Intertransversales.
Rectus Capitis Posticus Major.
Rectus Capitis Posticus Minor.
Rectus Capitis Posticus Laterale.
Obliquus Capitis Minor.
Obliquus Capitis Major.

Henle defines first a superficial group of sheath-like muscles passing from the spinous processes outward. It includes the Trapezius, Rhomboideus, Latissimus Dorsi (with Teres Major), the two posterior Serrati, and Splenius. He includes in his second group all the remaining muscles.

the ilium. It is seen to give origin to the Latissimus Dorsi muscle, and to protect and in part give origin to the Erector Spinæ. When the extrinsic muscles of the superior extremity and the Posterior Superior Serratus muscles are removed, it is seen to pass upward, covering in the Erector Spinæ and the Splenius muscles, while affording origin to the Inferior Posterior Serrate muscle. It here constitutes the vertebral aponeurosis of the English writers.

The Second Group of muscles of the back embraces—

The Levatores Costarum.
The Serratus Posticus Superior.
The Serratus Posticus Inferior.

THE LEVATORES COSTARUM.

The Levatores Costarum arise from the tuberosity and the transverse processes of the last cervical vertebra, and from the transverse processes of all the dorsal vertebræ but the twelfth. The fibres pass downward and outward in each case to the upper border and the posterior surface of the rib next below between the tubercle and the angle.

Use.—To elevate the ribs.

Variation.—Each muscle is inclined to undergo longitudinal cleavages, by means of which the superficial fibres are the longer, and are inserted into the second rib below the origin, while the deeper fibres reach to the rib directly below the origin.

Some fibres of the Levatores Costarum, namely, on the four last ribs, pass from the transverse process of the seventh dorsal vertebra to the ninth rib, and from the transverse process of the tenth dorsal vertebra to the twelfth rib. These are often called the Levatores Costarum Longiores. The Levatores Costarum are supposed to be specially differentiated slips of the external intercostal series of muscles.

THE SERRATUS POSTICUS SUPERIOR.

This muscle arises from the lower part of the ligamentum nuchæ, from the spines of the sixth and the seventh cervical vertebræ, and from the spines of the first and the second dorsal vertebræ. Its origin is aponeurotic. It is inserted by four digitations into the ribs from the second to the fifth.

Use.—To raise the ribs.

THE SERRATUS POSTICUS INFERIOR.

This muscle is larger than the preceding, and lies beneath the Latissimus Dorsi. It arises from the lumbar aponeurosis in the region of the tenth to the twelfth dorsal vertebra, and the upper lumbar vertebræ. It passes as a broad thin fleshy sheet upward and outward to be inserted into the lower borders of the eighth to the twelfth ribs.

Use.—To depress the ribs.

Variation.—The muscle may fuse with the Latissimus Dorsi.

The Third Group is composed of—

- The Extensors.
  - Splenius Colli.
  - Interspinales.
  - Rectus Capitis Posticus Major.
  - Rectus Capitis Posticus Minor.
- The Flexors.
  - Longus Colli.[1]
  - Rectus Capitis Anticus Minor.
  - Rectus Capitis Anticus Major.
- The Lateral Tractors.
  - Intertransversales.
  - Rectus Capitis Lateralis.
  - Trachelo-Mastoid.
- The Rotators.
  - Splenius Capitis.
  - Complexus.
  - Obliquus Capitis Superior.
  - Obliquus Capitis Inferior.
  - Semispinales Colli et Dorsi.
  - Multifidus Spinæ.

SPLENIUS CAPITIS ET COLLI.

The Splenius muscle arises from the spines of the fifth, sixth, and seventh cervical vertebræ, and the spines of the dorsal vertebræ as far as the third or fourth. Its fibres pass upward and outward, and divide ordinarily into two sets of fasciculi. The lower fasciculus is inserted into the transverse processes of the second and third cervical vertebræ; while the upper is inserted into the skull at the mastoid process and the superior semicircular line.

For convenience the two divisions of the Splenius are described together. The functional differences between the cervical and occipital portions should, however, be borne in mind.

Use.—In part to turn the head and neck. Acting with the more superficial muscles at the nape of the neck, the Splenius can extend the head on the spine, and extend the cervical portion of the spine.

Variations.—Sometimes the two divisions are not apparent. A slip is often derived from the lower division, which is identical with the Levator Anguli Scapulæ.—A slip may be traced to the occipital bone and the mastoid process of the temporal bone.

[1] The Longus Colli is described on p. 263.

Relations.—Above it lie the Trapezius, Rhomboid, and Serratus Posticus Superior. At the skull it lies beneath the thin aponeurotic tendon of the Sterno-Cleido-Mastoideus. Below it are the Complexus and Trachelo-Mastoid muscles.

The anterior border of the Splenius Capitis may be mistaken for a cervical lymphatic gland.

THE INTERSPINALES.

These are short symmetrical bundles lying between the spinous processes of the vertebræ, the spaces between the processes of the third and the tenth dorsal alone excepted. They are best developed in the neck.

Slips pertaining to the Interspinales are seen in the cervical region overlying the spinous processes. These have received the name of the Supraspinales.

Use.—To aid in extending the vertebræ.

THE RECTUS CAPITIS POSTICUS MAJOR.

This arises from the spine of the axis, and passes obliquely upward and outward to be inserted into the inferior semicircular line of the occipital bone.

It is homologous with an Interspinalis.

Use.—To aid in extending the vertebræ.

THE RECTUS CAPITIS POSTICUS MINOR.

This lies beneath the Rectus Capitis Posticus Major. It arises from the posterior tubercle of the atlas, and is inserted into the inferior semicircular line of the occipital bone.

It is analogous to an Interspinalis muscle or Semispinalis Colli.

Use.—To aid in extending the vertebræ.

THE INTERTRANSVERSALES.

These are short vertical muscles, passing between pairs of adjoined transverse processes. An anterior and a posterior slip are recognized. They are best developed in the cervical region, and least so in the dorsal, where in the upper portion they are absent.

Use.—To aid in lateral traction of the spine.

The anterior slips may be said, strictly speaking, to connect the transverse processes; the posterior are associated with the oblique processes.

The Extensor Coccygis of lower animals appears to be composed of excessively developed elements of the Intertransversales.

RECTUS CAPITIS LATERALIS.

The Rectus Capitis Lateralis arises from the free end of the transverse process of the atlas, and is inserted into the jugular process of the occipital bone.

Use.—To aid in lateral traction of the head on the spine.

THE TRACHELO-MASTOID.

This muscle arises from the transverse and articular processes of the four lower cervical vertebræ and the three upper dorsal vertebræ, ascends directly upward, and is inserted upon the mastoid process.

Use.—To draw the head backward and to rotate it.

Variation.—It is often fused with the Transversalis Cervicis.

THE COMPLEXUS.

The Complexus muscle arises from the transverse processes of the four lower cervical and the three upper dorsal vertebræ, as well as from the articular processes of the cervical vertebræ from the third to the sixth. A slip situated at its median margin, and usually marked by a transverse inscription, is often described as a separate muscle under the name of Biventer Cervicis.

Use.—To rotate the spine at the cervical region.

The origin of the muscle may include the dorsal spines as far down as the seventh.

Variations.—The Complexus may in part fuse with the Trachelo-Mastoid or the Longissimus Dorsi.

THE OBLIQUUS CAPITIS SUPERIOR

arises from the tips and upper surface of the transverse process of the atlas, and passes obliquely upward and inward to be inserted into the occipital bone at the inferior semicircular line.

Use.—To aid in rotating the vertebræ.

THE OBLIQUUS CAPITIS INFERIOR

arises from the spinous process of the axis, and passing obliquely upward and outward is inserted into the transverse process of the atlas.

Use.—To aid in rotating the vertebræ.

THE SEMISPINALIS COLLI.

The Semispinalis Colli extends from the transverse processes of the first four or five dorsal vertebræ, and is inserted into the spines of the cervical vertebræ from the second to the fifth.

Use.—To aid in rotating the cervical vertebræ.

THE SEMISPINALIS DORSI.

The Semispinalis Dorsi arises from the transverse processes of the dorsal vertebræ from the fifth to the tenth, and is inserted into the spines of the last two cervical vertebræ and the first to the fourth dorsal vertebræ.

Use.—To aid in rotating the cervical vertebræ.

THE MULTIFIDUS SPINÆ.

The several bundles of the Multifidus Spinæ arise from the articular and transverse processes of the vertebral column from the sacrum to the axis, and are inserted into the spinous processes. They are short, and each may include simply the distance from its origin to the spine of the next vertebra above. Many, however, pass to the second or third spine. Compared with the size of the muscle the quantity of fibrous tissue within it is unusually great.

In the sacral region fasciculi arise from the groove on the back and the lateral sacral crest; in the lumbar, from the mammillary processes; in the dorsal, from the transverse processes; and in the cervical, from the articular processes of the four lower vertebræ.—A deeper set, which is developed in the dorsal region, and which passes from the transverse processes to the laminæ of the vertebræ above, has received the name of the Rotatores Spinæ.

Use.—To aid in rotating the vertebræ.

Remarks.—The post-cervical muscles when divided, as by a sabre-cut, allow the head to sag forward, and the chin to rest upon the sternum as remarked by Larrey.[1] It follows that, in order to preserve the rest necessary to secure union between the lips of such a wound, the head must be supported in an upright position.

The tension of the muscles of the back has been shown to be sufficient to squeeze out the contents of an encephaloid tumor situated upon the back.[2]

A ball can gravitate from the occiput to the sacrum. An enormous abscess beneath the skin of the back may be caused by the unsuspected presence of such a missile. The collection will be limited below by the crests of the iliac bones, and by the posterior sacral aponeuroses. Illustrative cases are mentioned by Portal,[3] and were observed by the author during the American civil war.

The muscles of the back are not efficient in maintaining the erect position of the body, but guide and limit its movements.

The cervical muscles, while consisting of differentiations of the muscular layers pertaining to the region of the back, are often the factors in torticollis and in associated conditions with which the lower muscles have little or nothing to do. M. J. Moses,[4] in the course of a careful study of these muscles in relation to the treatment of a case of traumatic torticollis, found that the Sterno-Cleido-Mastoideus muscle was not the primary cause of the deformity, but that it was due to an inflammation occurring in the neck on one side, with resulting contraction of the whole or part of the following muscles: The Trapezius, Splenius Capitis, Rectus Posticus Capitis Major, Rectus Posticus Capitis Minor, Obliquus Superior, and Obliquus Inferior behind; and the Rectus Capitis Anticus Major, Rectus Capitis Anticus Minor, and Rectus Capitis Lateralis in front.

Dr. John Struthers[1] found the muscles normally arising from the spinous process of the axis displaced to the spinous process of the third vertebra. The spine of the axis lacked its usual bifurcation and great size. The inferior oblique retained a small slip of origin from the axis. It was held by this observer that the epispinous bones (represented in the two tubercles which are usually developed from the spinous process of the axis for the attachment of the Rectus Major and the Obliquus Inferior muscle) had by some unknown cause become detached, and had slipped to the spine of the adjoining vertebra below.

[1] Memoirs, i. 313.
[2] Holmes's System of Surgery, i. 523.
[3] Anatomie Médicale, ii. 12.
[4] New York Med. Journ., 1873, xvii. 58.

The Muscles of the Thorax.

The muscles of this group are the following:—

The Intercostals.
The Triangularis Sterni.

THE INTERCOSTAL MUSCLES.

The Intercostal muscles are two in number for each intercostal space. They constitute a series of eleven muscles situated on either side of the thorax.

The Internal Intercostal muscle occupies the deeper of the two planes of the intercostal space. It fills the anterior portion, namely, from the angle of the rib forward to the sternal extremity. Its fibres are directed obliquely downward and *backward*.

An aponeurotic extension is continued backward from each muscle to the vertebræ.

Under the name of the Subcostal muscles are included a few subpleural fasciculi which are separated from the plane of the intercostal muscles, and which pass over two or three intercostal spaces.

The External Intercostal muscle lies to the outer side of the Internal; its fibres are directed downward and *forward*, and are to be found from the tubercles of the ribs forward to near the ends of the costal cartilages. At this point they are continuous

[1] Edinburgh Med. Journ., May, 1863, 1041.

with the fascial extension passing in front of the sternum.

Use.—Concerning the functions of the intercostal muscles observers are by no means agreed. The writer has taught that the External Intercostals raise the ribs, and that the Internal Intercostals depress them. In the spaces between the costal cartilages it appears that both muscles depress the cartilages.[1]

THE TRIANGULARIS STERNI.

The Triangularis Sterni muscle, also known under the names of the Sterno-Costal and Transverse Thoracic, arises from the lateral margin of the lower portion of the gladiolus, from the upper half of the ensiform cartilage, and from the sternal ends of the fifth and sixth costal cartilages. Its fibres diverge to be inserted by fleshy digitations into the costal cartilages and into the sternal ends of the ribs from the fifth or sixth to the second.

This muscle is believed to be an upward extension of the Transversalis Abdominis.

The Diaphragm.

The Diaphragm is a musculo-tendinous septum between the thorax and the abdomen. It is wider from behind forward than from side to side. Above it is in contact with the pleuræ and the pericardium; and below with the peritoneum.

Since the tendinous fibres are central and continuous with the complicated peripheral muscular fibres, it is well to arrange the description under the following heads: (*a*) Muscular fibres arising from the bodies of the vertebræ; (*b*) Muscular fibres arising from the transverse processes of the vertebræ and the associated structures; (*c*) Muscular fibres arising from the side of the thorax; (*d*) The central tendon.

(*a*) The muscular fibres arising from the bodies of the lumbar vertebræ from the first to the fourth are called the *crura*. They ascend to decussate in the posterior central margin of the Diaphragm to inclose the aortic orifice, thence to diverge to define the œsophageal orifice, again to converge to limit this orifice anteriorly at the edge of the central tendon.

(*b*) The fibres from the transverse processes are short and broad, and continuous with the preceding. They pass directly upward into the lateral posterior portions of the tendon. They likewise arise from the *ligamenta arcuata*—a name given to the arches of tendinous fibres passing from the body of the first lumbar vertebra over the Psoas muscle to the end of the transverse process (*ligamentum arcuatum internum*), and from the last-named point to the last rib (*ligamentum arcuatum externum*).

(*c*) The costal portions arise from the inferior margins of the thorax from the last six or seven ribs and the ensiform cartilage, interdigitating with the origin of the Transversalis Abdominis muscle. These fibres are shorter than the vertebral. They are weakest opposite the ensiform cartilage, where indeed the peritoneum and pericardium often lie in contact.

(*d*) The central tendon. This is more or less trilobed, the middle portions answering to the deficiency of the ensiform muscular fibres; of the lateral portions the right is somewhat the longer. It is pierced by an opening, *foramen quadratum*, for the passage of the inferior vena cava and a branch of the phrenic nerve.

The foramina of the Diaphragm, as above indicated, are three in number: the aortic, œsophageal, and the *foramen quadratum*.

The *aortic* is defined at the sides by the tendinous fibres at the median edges of the decussating crura, and behind by the bodies of the vertebræ. In addition to the aorta it transmits the thoracic duct and azygos vein.

The elliptical *œsophageal foramen* is embraced by muscular fibres of the crura. Occasionally its anterior portion is tendinous. It transmits the œsophagus and the pneumogastric nerves.

The *foramen quadratum* is described above under section (*d*).

The great splanchnic and other sympathetic nerves pass through the Diaphragm to the outer side of the crura, or they may sometimes, in part, pierce their structure.

The left convexity of the diaphragm usually extends from one to two ribs below the level of the right. Instead of the left being oval, like the right, it is more of a half-moon shape; the greater portion of it is behind, owing to the position of the ventricles and apex of the heart in front of the left side of the chest.[1]

Use.—The Diaphragm is the chief muscle of respiration. It is to the base of the thorax what the Leva-

[1] For an account of the different views concerning the action of these muscles the reader is referred to Quain's Anat., 8th ed., vol. i. 312; Kuss's Physiologie, Amer. ed. Note, 290; A. W. Volkmann's Zeit. für Anat. und Entwickelungsgesch., ii. 1876, 159; Martin and Hartwell, Journ. of Physiology, ii., 24; W. W. Keen, Trans. College of Physicians of Phila., i. 3d Series, 97. L. Traube, Gesammelte Beiträge zur Pathologie und Physiologie, Berlin, i. 142–183, 1871. A. Ransome, Proc. Roy. Soc., Nov. 22, 1872.

[1] Sibson's Medical Anatomy, Col. 41.

tor Ani and Sphincter Ani muscles are to the inferior trunkal plane, and what the Mylo-Hyoid muscle is to the floor of the mouth. It descends in inspiration, and becomes slightly flattened; it ascends in expiration, and becomes convex. Moderate stimulation of the fibres of the muscle in a living animal will cause only those fibres receiving the stimulus to contract. Pronounced stimulation will throw the entire muscle into contraction. In tranquil breathing the muscle ascends about one inch. The right half reaches a point as high as the fifth rib, *i. e.*, about two inches below the nipple. It may, under favorable conditions, ascend as high as the fourth costal cartilage.

Remarks.—Diaphragmatic hernia: This rare form of hernia is usually seen in the left side, owing probably to the imperfect support here observed as compared with the right. It may occur through a scar caused by a gunshot wound or by any old injury. The opening may be in the middle of the left leaflet, and barely admit the tip of the forefinger, or it may allow a loop of the transverse and descending colon to pass together with a large portion of the omentum A case is recorded by Chas. W. Chancellor,[1] in which a knuckle of the transverse colon and jejunum had passed through an artificial opening in the middle of the left leaflet. Instances are known in which the pyloric end of the stomach passed into the thorax through a diaphragmatic rupture.

The Diaphragm may be congenitally imperfect. Gilman Davies[2] met with an instance in which the left leaflet was defective, excepting at its posterior portion. The intestines, from their origin to the lower portion of the large intestine, were lodged in the thorax.

Severe violence, as compression of the lower part of the chest between the cars of a railway train, may cause rupture of both the muscular and the tendinous structure of the Diaphragm. Vincent Jackson[3] mentions such a case; the rent beginning near the middle line in the neighborhood of the vertebral column, and extending thence obliquely upward and outward, but not quite reaching the thoracic wall. The rent admitted the stomach, spleen, transverse colon, and part of the small intestine.—The rupture sometimes occurs in the muscular structure only, and extends in the direction of the fibres. In a case described by Kendall[4] the slit was four inches long. Through this opening the stomach, transverse colon, and about two feet of the small intestine had protruded.

Palpitation of the heart, when associated with a state of inanition, is, according to Winslow and Portal,[1] due to the weight of the liver, stomach, and intestines making traction upon the Diaphragm.

Owing to its comparatively loose texture, and to its intimate relation both to abdominal and thoracic organs, the Diaphragm transmits inflammatory changes. Hepatitis and nephritis may thus secondarily induce pleurisy and pneumonia. An abscess between the liver and the thoracic wall may excite empyema. An abscess above the Diaphragm may rupture the muscle and permit the pus to escape into the abdomen, while on the other hand hepatic abscess may perforate the Diaphragm, allowing pus to enter the thorax.

The vault of the Diaphragm can be forced by abdominal tumors to a higher point than that mentioned in the text. It has been found under these circumstances as high as the third or even the second dorsal vertebra, or as high as the second rib on the right side, and the fourth rib on the left.[2]

The descent of the Diaphragm in respiration is greater than the descent of the liver, thus showing on theoretical grounds that the liver may be compressed.

The Diaphragm has been known to be perforated by fragments of a fractured rib.[3] It is difficult to surmise how a wound penetrating the chest walls at the lower ribs during expiration can fail to penetrate also the diaphragmatic fibres.—In advanced post-mortem digestion of the stomach the Diaphragm is often involved.[4]

Muscles of the Abdomen.

The muscles in the region of the abdomen are—

The External Oblique.
The Internal Oblique.
The Transversalis.
The Rectus.
The Pyramidalis.
The Quadratus Lumborum.

THE EXTERNAL OBLIQUE.

The External Oblique muscle, the most external of its group, is a broad sheet of muscular tissue ex-

[1] Amer. Journ. Med. Sci., Oct. 1855, 405.
[2] Amer. Journ. Med. Sci., Jan. 1846, 127.
[3] Med. Times and Gazette, March, 1858, 318.
[4] Med. Times and Gazette, 1865, 253.

[1] Anatomie Médicale, tom. v. 94.
[2] Bonnet, Traité complet des Maladies du Foie, 1841, 187.
[3] Carle Morgan, Trans. Path. Soc. London, 1873, 173.
[4] P. H. Bernard, quoted in Richet, Anat. Chirurg., 564.

tending from the thorax to the innominate bone, and constituting in part the side and the front of the abdominal wall. It arises from the anterior outer surfaces of the ribs from the fourth to the twelfth. Above, it interdigitates with the origin of the Serratus Magnus, from the fourth to the eighth rib, and below with the Latissimus Dorsi.

The posterior fibres pass vertically downward from the last ribs, and are inserted fleshy into the outer lip of the crest of the ilium. The remaining fibres pass obliquely downward and inward, and are inserted into the linea alba and Poupart's ligament.

Poupart's ligament is a tendinous extension lying between the anterior superior spinous process of the ilium and the pubis. It is continuous above with the aponeurosis of the External Oblique muscle, and below with the fascia of the thigh. At its insertion it aids in forming the external abdominal ring.

The *external abdominal ring* is an oblique narrow triangular opening situated one inch to the outer side of the pubis, and designed for the escape of the spermatic cord. It is bounded externally by Poupart's ligament, and internally by the aponeurotic fibres of the External Oblique muscle. The outer border is called the *outer column* or *pillar*, and the inner the *inner column* or *pillar*. A small number of sparsely distributed curved fibres stretching from one to the other have received the name of the *intercolumnar fibres;* these, becoming strengthened below, have been called the *intercolumnar fascia.*

Relations.—Below is the Internal Oblique muscle, a small fasciculus of which lies beyond the posterior vertical fibres.

THE INTERNAL OBLIQUE.

The Internal Oblique muscle (Plate L. fig. 2) is situated beneath the External Oblique. It is a broad sheet of muscular fibre extending upward and forward, and thicker in the middle than at the sides. It arises from the lumbar aponeurosis, from the crest of the ilium and its anterior superior spinous process, and from the outer half of Poupart's ligament.

The fibres from the lumbar aponeurosis and the beginning of the iliac crest pass nearly vertically upward, and are inserted into the twelfth rib. Those arising from the remaining portion of the iliac crest pass obliquely forward and upward, and are inserted into the lower margin of the cartilages of the ninth to the eleventh ribs and into the ensiform cartilage and the linea semilunaris of the abdominal wall; while those arising from Poupart's ligament pass forward in a radiating manner into the *linea semilunaris*, and into the tendinous structures continuous with it at the symphysis pubis.

The aponeurosis of the muscle is broader above than below, and extends from the inferior margin of the thorax to the Rectus Abdominis at the outer border of which it divides, the one portion going in front to be lost in the aponeurosis of the External Oblique, the other passing behind to be continuous with the aponeurosis of the Transversalis muscle. The anterior portion is weaker than the posterior, and is abruptly terminated about midway between the umbilicus and the pubis to form the *semilunar fold of Douglas.*

But while the Rectus at this part of the abdomen is thus weakened, it is strengthened in front by the undivided aponeurosis of the Transversalis, and at the side by the union of the aponeuroses of the Internal Oblique and Transversalis muscles. This union constitutes the so-called "conjoined tendon," which is inserted into the symphysis pubis.

The Cremaster muscle is a special arrangement of the fibres of the Internal Oblique muscle which descends in front of the spermatic cord. It is attached at the inner end to Poupart's ligament and to the spine and crest of the pubis. Between these points the loop-like fibres dip down and are incorporated with the *cremasteric fascia.*

A transverse line (*linea transversa*) often extends from the tenth rib; less frequently a similar one corresponds in position to the eleventh.

THE TRANSVERSALIS.

The Transversalis muscle (Plate L. fig. 3) arises from the deep or anterior layer of the vertebral aponeurosis, from the lower borders of the six lower ribs, and from the inner lip of the iliac crest at its anterior two-thirds. Its fibres are of unequal length, the middle being the longest. It unites with the Internal Oblique at the origin of the latter from Poupart's ligament, and at the conjoined tendon, as already noticed. It is inserted by a thin aponeurosis into the posterior layer of the sheath of the Rectus muscle, except at the lower portion where it joins the Internal Oblique in passing in front. The aponeurosis is narrower than the other abdominal muscles.

THE RECTUS ABDOMINIS.

The Rectus Abdominis muscle arises from the upper border and anterior surface of the pubis. It passes upward as a broad ribbon-shaped muscle, and is inserted into the outer sides of the cartilages of the fifth, sixth, and seventh ribs, and the ensiform

cartilage. It is remarkable for the tendinous transverse lines interrupting the vertical bundles composing it. These lines have received the name of the *lineæ transversæ* (*inscriptiones tendineæ*), and are disposed as follows: one opposite the navel, one halfway between it and the ensiform cartilage, and one opposite that cartilage. A fourth, though incomplete, often divides the tract between the navel and the pubis.

Relations.—The rectus muscle is in part inclosed in a sheath, already described (see External and Internal Abdominal Muscles).

The Linea Alba.—This is a white fibrous band formed by the intimate union of the aponeuroses of the Oblique and Transversalis muscles. It occupies the interval between the Recti muscles, and embraces the umbilicus. It is slightly broader above than below, where a larger number of longitudinal fibres are seen.

The *linea alba* is a favorite locality for incision in ovariotomy, and in the high operation for stone in the bladder.

The Linea Semilunaris.—This resembles the linea alba in construction, but is curved and lies to the outer side of the Rectus muscle. Each line is about three inches from the umbilicus.

Remarks.—The Rectus may be ruptured by muscular exertion. A good example of this is presented by C. Holthouse.[1]

A man while tying up a scaffold pole, both his hands being raised for that purpose, suddenly stepped from the plank upon which he was standing, and saved himself from falling by hanging on with his hands, his body being suspended in the air. At the same instant he felt a sudden tear in the region of the Rectus muscle.

In a case reported by S. B. Richardson,[2] the rupture involved all the fibres of the muscle of the right side at a point two inches below the umbilicus. The corresponding deep epigastric vessels and nerves were also completely severed. A hæmatoma ensued, accompanied by symptoms of peritoneal irritation, which were supposed to indicate ventral hernia. An exploratory incision was made and the clot turned out. The patient, a male of twenty-eight years, recovered.

The muscle may be ruptured in tetanus.[3] In a case reported by Curling[4] the muscle of the right side, about one inch above the pubis, was found after death to be torn transversely. Sédillot,[1] in collecting the cases of ruptured muscle, found that thirteen in twenty-one occurred at the termination of the muscular fibres in the tendon, while eight occurred in the fleshy fibres alone.

Rupture of the Rectus with hemorrhage is not infrequent in typhus and typhoid fever. Zenker[2] shows that such lesions are due to disintegration of the muscular fibres. He describes two forms, one in which the sheathed structure of the muscle disappears, and in which the sarcous matter is converted into a quantity of minute granules; and the other in which the sarcolemma becomes filled with masses of a transparent strongly refracting waxy substance. Murchison describes[3] an abscess occurring in the Rectus muscle of a man, thirty-seven years of age, who died of typhoid fever.

The sheath of the Rectus may be the seat of an enormous abscess, which, according to Mr. Adams,[4] may have its origin in the symphysis pubis.

Contraction of the bellies of the Recti muscles, owing either to inflammation of the subjacent peritoneum or stomach, or in cases of increased muscular irritability, to the mere application of the hands, is frequently mistaken by inexperienced observers for hepatic enlargement.

The spaces between the Abdominal muscles and between the Rectus and its sheath may serve for the location of abscesses and for fistulous tracts. In neglected abscess about the hip-joint, pus has been known to point far up the abdominal wall, having found its way thither between the Oblique muscles. If a collection either of air, pus, or blood lies in the space between the External Oblique muscle and the skin, it can be distinguished from one more deeply situated, by the fact that it is arrested at Poupart's ligament.

THE PYRAMIDALIS.

This muscle is of a triangular shape as the name implies, and rests within the sheath of the Rectus. It arises from the horizontal ramus of the pubis close to the symphysis. It ascends along the inner border of the Rectus, and is lost within the linea alba.

[1] Trans. Path. Soc. London, xiii. 1862, 263.
[2] American Journ. Med. Sci., Jan. 1857, 41.
[3] Francis Mason, Trans. Path. Soc. London, 1868, 448.
[4] Ibid., 1865, 235.

[1] Mém. et Prix de la Soc. de Méd. de Paris, 1817.
[2] Ueber die Veränderungen der wilkurlichen Muskeln im Typhus Abdominalis, Leipzig, 1864.
[3] Trans. Path. Soc. London, xvi. 275.
[4] Trans. Path. Soc. London, v. 1854, 245.

THE QUADRATUS LUMBORUM.

The Quadratus Lumborum lies on the posterior wall of the abdomen, and occupies the interval between the transverse processes of the lumbar vertebræ, the last rib, and the innominate bone.

It arises from the posterior portion of the iliac crest and the ilio-lumbar ligament, and is inserted by tendinous slips into the transverse processes of the four upper lumbar vertebræ, and by a broad tendon into the inferior border of the twelfth rib.

Accessory tendinous slips arise from the inferior transverse processes, and join the muscle near its insertion into the rib.

Use.—The anterior portion of the Quadratus muscle is considered by Meyer to be functionally distinct from the posterior. The former he identifies as a Scalenus Lumborum, and as a depressor of the last rib, while he holds the latter to be an Ileo-Lumbalis and a tractor of the lumbar vertebræ.

The muscle strengthens the posterior wall of the abdomen.

Remarks.—The muscle is incised in colotomy and in nephrotomy. It is the frequent seat of pseudo-neuralgic pains grouped under the name of lumbago. The region of the loin, which in a general way is embraced within the limits of the two Quadrati and the dorsal surface of the lumbar portion of the spine, is the site to which the pains of the kidney are referred.

IV. THE MUSCLES AND FASCIÆ OF THE UPPER EXTREMITY.

(1) The Muscles.

The muscles of the upper extremity embrace an extrinsic and an intrinsic set.

The Extrinsic muscles include the following:—

The Trapezius.
The Latissimus Dorsi.
The Rhomboideus.
The Levator Anguli Scapulæ.
The Pectoralis Major.
The Subclavius.
The Pectoralis Minor.
The Serratus Magnus.
The Deltoid.[1]

[1] The Deltoid is, in a strict sense, an intrinsic muscle. It has been included in the extrinsic set for the reason that its relations are with the Trapezius, with which it is fused in the majority of animals.

All the remaining muscles of the upper extremity belong to the intrinsic set.

THE TRAPEZIUS.

The Trapezius presents a triangular figure, the base of which rests along the line of the vertebral spines, the apex being directed toward the shoulder. The upper or occipital border is rounded, while the lower or dorsal is pointed.—The muscle arises by a thin aponeurosis from the occipital bone at the protuberance, and at the median third of the superior semicircular line; from the ligamentum nuchæ, the lower cervical and all the dorsal spines, as well as from the supraspinous ligaments between them.—The upper fibres pass downward, outward, and forward to be inserted into the upper border of the spine of the scapula its entire length, and also into the acromion and the acromial end of the clavicle.—The lower fibres, from the third to the twelfth dorsal spines, pass upward to glide over the triangular area at the base of the spine, and to be inserted by a narrow tendon into the median or axillary half of this portion of the scapula.

Use.—The Trapezius, when acting as a whole, fixes and serves to maintain the position of the scapula against the trunk, an action in which it is assisted by the Serratus Magnus.—The upper fibres can raise the scapula and the clavicle.—The middle fibres tend also to raise the scapula by increasing the obliquity of its spine, and by elevating the glenoid angle. They are of special use in fixing the scapula in this position preparatory to the action of the Deltoid and the Supra-Spinatus muscles.—The ascending fibres draw the scapula downward and backward to the position of rest, thus antagonizing the remaining fibres. The ascending fibres may aid the Latissimus Dorsi.

When the insertion of the Trapezius is fixed, the upper fibres draw the head backward and outward toward the shoulder.—When both sides act conjointly, the head is pulled directly back.—When the body is suspended by the raised upper extremity, the lower fibres can twist the vertebral column toward the shoulder.

The description of the Trapezius embraces the following details:—

The muscle arises entirely by tendinous points, which at the occiput are closely adherent to the skin, and are of a dull ligamentous hue.—From the sixth cervical to the third dorsal spine the fibres of origin are glistening and conspicuous. They increase in length toward the base of the neck, and abruptly diminish at the upper dorsal spines, and

form with the fibres of the muscle of the opposite side an elliptical aponeurotic space. The fibres from the remaining four spines are short, but again become conspicuous toward the last three dorsal spines, where, in conjunction with the corresponding slips of the opposite side, a small triangular space is seen, whose base is directed upward. The fibres of insertion of the upper set are musculo-tendinous, and short toward the clavicle and acromion, while those received along the spines are distinctly tendinous.—The fibres of insertion of the lower set end in a small triangular aponeurosis, which is received upon the triangular eminence at the root of the spine of the scapula. A small bursa was found by Luschka and Synnestedt beneath this tendon.

The Variations of the Trapezius embrace: (1) Errors of cleavage, by which the occipital, cervical, and dorsal portions may be distinct from one another, or by which a deeper lamina may pass from some of the transverse cervical processes to the humerus (Occipito-Humeral muscle), or to the clavicle (Occipito-Clavicular muscle), or by which a deep fascicle may pass from the occiput to the scapula (Occipito-Scapular muscle). These variations are reversions to the forms of the muscle seen in quadrupeds. (2) Errors of fusion, by which either the occipital or the clavicular fibres unite with adjacent portions of the Sterno-Cleido-Mastoideus muscle. (3) Errors of defect, seen in both origin and insertion. Thus the occipital portions may be absent, and fewer vertebræ be included in the origin than is normal.—In the same manner the clavicular portions may be absent.

THE LATISSIMUS DORSI.

This, the broadest muscle in the body, is of a rectangular shape. It arises from the lower four or six dorsal vertebræ (where it is covered by the lower portion of the Trapezius), from the aponeurosis connected with the spinous processes of the remaining dorsal vertebræ, from the spinous processes of the sacrum, and from the posterior portion of the outer lip of the innominate bone. A few muscular fibres of origin arise from the pelvis to the outer side of the aponeurosis, and yet others from the last three or four ribs. The muscle is directed upward and outward, and crosses the angle of the scapula. Its fibres here converge and wind around the Teres Major to form a flat quadrilateral tendon about two inches in length, which is inserted in the posterior lip of the bicipital groove of the humerus.

Use.—This varies according to the position of the arm. When the arm is elevated, the muscle aids in depressing and drawing it backward; when the arm hangs at the side, it pulls the arm backward and toward the buttock. Hence the Latin names given it of the *Tersor Ani* and the *Scalptor Ani*. When the Trapezius and the Rhomboideus are atrophied, the Latissimus Dorsi draws the scapula toward the spine.

Nerve.—The muscle is supplied by the subscapular nerve and the intercostal nerves.

The fibres of origin are composed of two sets: one, the thin, small slips covered by the Trapezius muscle; and the other, more extensive, arising from the lumbar aponeurosis. —The upper fibres of the muscle are horizontal, the lower oblique; those arising from the pelvis and the ribs are vertical.—As the muscle passes over the inferior angle of the scapula it receives quite constantly a special fasciculus from it. —Beyond the inferior angle the muscle is slightly twisted, so that the inferior border is at first anterior and then superior, while the superior, or horizontal, is afterward inferior.—The tendon is at first adherent to the tendon of the Teres Major, but becomes free prior to insertion.—The tendon may be inserted at the bottom of the bicipital groove, or at the base of its inner lip. It extends a little higher than the tendon of the Teres Major, and occasionally sends a fibrous slip as far as the lesser tuberosity.

The Variations of the Latissimus Dorsi are of two kinds. (1) Variation in origin: The origin from the dorsal spines may include the fourth dorsal; accessions may come from the eighth dorsal, and from the ninth rib.—The iliac origin may be absent. (2) Variation in insertion: Slips may pass to the capsule of the shoulder-joint, to the coracoid process, to the fascia of the arm, and to the Pectoralis Major, Teres Major, and Serratus Magnus muscles. Some of these slips may be separated from the main muscle by inscriptions. The last-named variations are suggestive of the arrangement in quadrupeds, in some of which the Latissimus constantly effects important fusions with the Pectoralis Major, and sends slips down the anterior extremity, often as far as the elbow, or in some forms even to the wrist.

Relations.—In front of the tendon, just prior to the insertion, lie by direct relation the musculo-spiral nerve and its muscular branch to the Triceps. Still further in front, by indirect relation, lie the axillary vein and artery, the musculo-cutaneous, ulnar, and median nerves. The muscle forms the posterior wall of the axilla.

THE RHOMBOIDEUS.

The Rhomboideus muscle consists of two slips: the Rhomboideus Major and the Rhomboideus Minor. The Rhomboideus Major arises partly by short tendinous slips, and partly by a short aponeurosis from the dorsal spines of the four upper dorsal vertebræ and the corresponding supra-spinous ligaments. It passes downward and outward without suffering diminution, and is inserted into the inner margin of the vertebral border of the scapula.—The Rhomboideus Minor lies proximally to the Rhomboideus Major. It arises from the ligamentum nuchæ in the region of the lower cervical vertebræ, and from the first dorsal spine. It is inserted on the triangular space at the beginning of the spine of the scapula.

Use.—To draw the shoulder toward the middle line of the back, and to antagonize the tendon of the Trapezius in rotating the scapula. Acting with the Teres Major it can depress the elevated humerus (Duchenne).

Nerve.—The muscle is supplied by a continuation of the nerve for the Levator Anguli Scapulæ.

The Variations of the Rhomboideus include: (1) A disposition to planar cleavage. (2) Slips of contribution to the Teres Major, Latissimus Dorsi, and Serratus Magnus muscles. (3) Arrests of development, by which the origin may be confined to a smaller number of spines than five, and the insertion to a portion only of the vertebral margin of the scapula.

The genealogy of the muscle includes slips passing upward to reach the atlas or even the occiput.

THE LEVATOR ANGULI SCAPULÆ.

This muscle arises from the posterior tubercles of the transverse processes of the upper four or five cervical vertebræ. The slips soon unite to form a flat narrow muscle which is inserted on the vertebral border of the scapula between the level of the spine and the superior border.

Use.—To raise the superior angle of the scapula, and when the scapula is fixed to move the neck laterally.

Nerve.—This is derived from a branch of the deep set of the cervical plexus.

Variations.—It may unite with the Serratus Magnus, and derive slips from the Trapezius. Its origin may reach as high as the transverse process of the atlas, or as low as the seventh cervical vertebra. Its insertion may not be limited to the angle of the scapula, but may include a portion of the upper border of the bone. It may send slips to the first and second ribs, to the Serratus Posticus Superior, to the Scalenus Medius, to the Splenius Capitis, and to the Complexus muscles. It may undergo longitudinal cleavage, and be composed of three to six slips.

THE PECTORALIS MAJOR.

The Pectoralis Major muscle arises from the median two-thirds of the clavicle, from the greater portion of the front of the sternum, from the first six costal cartilages, and from the aponeurosis of the External Oblique muscle of the abdomen. The fibres converge to be inserted into the outer margin of the bicipital groove of the humerus.

This muscle is a broad fleshy mass placed at the upper and anterior portion of the chest wall, and forms the anterior border of the axilla. Just prior to the formation of the tendon it is of a quadrate shape, and is rather coarsely fasciculated. The lower border of the muscle answers to the position of the fifth rib as it lies on the side of the thorax.

Use.—To adduct the humerus. The shoulder, when its muscles are fixed, can be raised by the clavicular fibres; these also act with the anterior fibres of the Deltoid and the Coraco-Brachialis in swinging the humerus forward. The sternal fibres draw the shoulder downward and inward, and depress the arm from the elevated position. In this act they are assisted by the Latissimus Dorsi and the Teres Major muscles.

Nerves.—These are derived from the anterior thoracic branches of the brachial plexus.

The Pectoralis Major consists of a clavicular and a sterno-costal portion separated by a horizontal interspace. This in emaciated subjects is sufficiently pronounced to be detected beneath the skin, and is marked when the arm is abducted.

The *clavicular portion* arises by short, tendinous fibres from the anterior border of the sternal half or two-thirds of the clavicle, and at times from the sterno-clavicular capsule and the outer border of the manubrium.

The *sterno-costal portion* arises by two imperfectly defined layers as follows: the superficial layer from the anterior surface of the sternum, and inferiorly by a slip from the anterior portion of the sheath of the Rectus Abdominis muscle; the deep layer by several irregular and inconstant digitations from the second to the sixth costal cartilage, and from the osseous part of the sixth rib.

The fibres from this extensive origin pass outward toward the humerus: the upper fibres, the most robust of all, tending downward, the middle fibres outward, and the lower fibres upward. They finally converge to constitute the inner wall of the axilla, at which point the clavicular fibres are found at the lower anterior portion, and the costo-clavicular fibres at the upper portion of the muscle. Thus, in part twisted upon themselves, the fibres form a pocket which is open above and occupied by fat and connective tissue, and occasionally by a bursa. The outer and inner walls of the pocket are formed by the clavicular and costal portions of the muscle, while the base is formed by their union.—The clavicular portion is inserted in the outer bicipital ridge of the humerus near the deltoid insertion. The costal portion here passes upward nearly parallel to the foregoing, and is inserted into the upper part of the ridge. Both portions are intimately held to the fascia of the arm.

The Variations of the Pectoralis Major arrange themselves into four divisions: (1) A disposition in common with other extrinsic muscles to send slips to the superior extremity beyond the bicipital ridge, or to the muscles about the shoulder-joint. Among these may be mentioned slips to the fascia of the arm, to the Latissimus Dorsi, to the Supra-Spinatus, to the Deltoid, and to the Biceps muscles. (2) A tendency to unite in part with the Deltoid and the Pectoralis Minor muscles, and to effect an extension of fibres to the Rectus Abdominis, and to the External Oblique.

(3) Excesses of development, by which the muscle may be doubled, by which fibres may pass across the median line to the muscle of the opposite side, and by which additional slips of origin may be secured from the seventh and eighth costal cartilages. (4) Defects of development, by which one or more of its three divisions may be absent.

Remarks.—The interval usually present between the Pectoralis Major and the Deltoid muscle serves as a guide to the position of the coracoid process of the scapula and the axillary artery. The rather loose connective tissue between the muscle and the Pectoralis Minor is sometimes the seat of abscesses. These do not tend to involve the axilla, since a tolerably firm layer of fascia extending from the clavicle and the coracoid process confines the pus to its sub pectoral bed. Very rarely enormous collections of pus form at the side of the chest, dissecting beneath the Pectoral, Serratus Magnus, and Latissimus Dorsi muscles.—Collections between the skin and the muscle do not involve the Deltoid by reason of a similar septum of fascia passing through the pectoro-deltoid interval from above downward to join the costo-coracoid membrane.

THE SUBCLAVIUS.

This little muscle is concealed by the coraco-clavicular fascia, and lies between the approximate surfaces of the clavicle and first rib. It arises from the upper surface of the first intercostal cartilage at its junction with the rib, and is inserted on the under surface of the clavicle at its outer part.

Use.—The Subclavius muscle fixes the clavicle to the thorax, and aids in preventing dislocation of the sterno-clavicular joint. It will be observed that the muscle will, in contracting, force the sternal end of the clavicle deep in its articulation. According to Sappey, when the clavicle is broken at its middle, the muscle acting with the adductors of the arm will pull in the outer fragment, which is thus placed below and a little in front of the inner fragment.

Among the Variations may be mentioned the following:—The muscle may be duplicated, *i. e.*, it may have two separate slips upon the first rib. A separate fasciculus may extend from the front of the sternum to the corresponding surface of the clavicle.[1]

At its origin the muscle presents a cylindroid compressed tendon. It soon assumes a bi-penniform appearance, the tendon appearing for the most part on the under surface of the muscle. At the middle of the mass the tendon is concealed. The fleshy fibres on the upper portion of the muscle are of different degrees of obliquity; those farthest from the insertion being but little inclined, while others are nearly parallel to the axis of the clavicle.

According to Henle, the costo-clavicular ligament passes for the most part behind the muscle.

The Supra-Clavicular Muscle.—Under this head Luschka describes a small slip, fleshy throughout, arising from the upper margin of the sternum, and inserted into the external end of the clavicle.

THE PECTORALIS MINOR.

The Pectoralis Minor muscle is placed at the side of the chest beneath the Pectoralis Major, which conceals it. It arises from the upper borders of the costal cartilages, from the third to the fifth, passes upward and outward, and is inserted into the coracoid process of the scapula.

Use.—To draw the scapula toward the thorax.

Nerves.—The Pectoralis Major and Minor muscles are supplied by the anterior thoracic nerves.

Above the muscle lies the Pectoralis Major, from which it is separated by a quantity of loose connective tissue. To the outer side, below, is the Serratus Magnus.

The Pectoralis Minor is a thin, delicate muscle, covered by a glistening fascia, which is continuous above with the costo-clavicular fascia, and below with an aponeurosis over the external intercostals. It is inserted upon the anterior half of the inner border and the upper surface of the coracoid process near its summit, and sends a thin layer outward to the tendon of origin of the Coraco-Brachialis. A bursa is often found beneath the tendon which has often been seen to communicate with the shoulder-joint. Günther mentions a case in which an abscess was found limited to the surface of the coracoid process corresponding to the insertion of the Pectoralis Minor.

Variations.—The lower border of the Pectoralis Minor rarely appears below the lower border of the Pectoralis Major.—The muscle may arise from the second to the fourth, or from the fourth to the sixth ribs, or may extend its line of insertion to the capsule of the shoulder-joint or to the humerus. Infrequently the muscle is inserted entirely upon the capsule.—A muscle, superficial to the Pectoralis Minor, may arise from the sternal ends of the first and the second ribs, and pass to the capsule of the shoulder-joint.[1]

THE SERRATUS MAGNUS.

The Serratus Magnus is a flat, nearly square muscle, placed at the side of the thorax, presenting a digitate oblique lower border, and extending from the ribs to the scapula. It arises by fleshy slips from the first to the eighth or ninth rib inclusive; passes backward and upward, following the general curve of the side of the thorax; and is inserted along the

[1] W. Gruber, Mém. de l'Acad. St. Petersbourg, 1860, 3, fig.

[1] W. Gruber, Mém. de l'Acad. St. Petersbourg, 1860, 3, fig.

vertebral border of the scapula between the insertion of the Rhomboideus muscle and the origin of the Subscapularis.

When the arm is raised from the vertical to the horizontal position, four obliquely placed muscular elevations are seen on the parietes of the trunk. They answer to the digitations of the Serratus from the sixth to the ninth.

Use.—The Serratus Magnus intervenes as a soft muscular cushion between the scapula and the sides of the chest. A bursa, which sometimes exists between it and the scapula, lessens friction. When the entire muscle contracts, the ribs being fixed, the scapula is drawn forward (adducted) and held firmly against the thorax, thus enabling the muscles arising from the scapula to secure definite lines of traction. The position described precedes the action of the Deltoid, the Coraco-Brachialis, the Pectoralis Major, the Pectoralis Minor, the Triceps, the Supra-Spinatus, the Infra-Spinatus, the Teres Major, and the Teres Minor muscles. The most important of these is the Deltoid, which cannot effectually raise the arm from the vertical to the horizontal position unless the scapula has been previously fixed by the Serratus Magnus.—When the entire muscle contracts, the scapula being retracted by the Levator Anguli Scapulæ, the Serratus, together with the Trapezius and Rhomboidei, assists in raising the ribs.—The Trapezius and Rhomboidei muscles may be considered as antagonistic in action to the Serratus in most of the motions of the scapula. The interval between the Serratus Magnus and the Rhomboideus, at the vertebral scapular border, may be, it is true, compared to an intermuscular septum, as seen in one of the semilunar lines of the abdomen; and Barwell[1] conceives that when the Serratus and the Rhomboidei act together, traction can be made, as though their fibres were component parts of a single muscle, from the fixed ribs directly to the yielding spinal column, and that this movement may, under favorable conditions, produce one of the varieties of lateral spinal curvature.—Paralysis of the Serratus will cause the scapula to be drawn upward by the action of the muscles named above, and the vertebral border to be notably projected from the sides of the body.—When the upper fasciculus acts independently of the rest of the muscle, it, together with the Pectoralis Minor, pulls forward and downward the glenoid scapular angle.[2]

[1] Lateral Curvature of the Spine, 1870, 30.

[2] For a careful study of the uses of the Serratus Magnus, see Busch, Langenbeck's Archiv für Klinische Chirurgie, 1863, 43; also Duchenne, Physiologie des Mouvements.

Nerve.—The Serratus Magnus is supplied by the posterior thoracic nerve.

The muscle may be divided into three portions, as follows: The first (upper) arises by a single slip from the lower border of the first rib, from the external face of the second, and from a fibrous band extending across the first interosseous space. It is inserted into the smooth triangular facet at the upper vertebral border of the scapula near the angle. This fasciculus is separated from the rest of the muscle by a narrow cellular interval. Instances have been recorded in which this slip was absent.—The second, or middle division, arises below the first, from the second, third, and fourth ribs, where the Pectoralis Minor is thin, and sometimes in part also from the aponeurosis of the External Intercostal muscle. Its fibres pass outward, spreading as they do so, to assume a fan-like form, and are inserted into the vertebral border for nearly its entire extent. This division may be absent, while the upper and lower are intact.—The third, or lower division, arises from the remaining ribs, viz., the fifth, sixth, seventh, eighth, ninth, and sometimes the tenth. The muscles of this division are arranged in a convex manner upon the ribs (the sixth slip being the most pronounced), and interdigitate with the upper fibres of origin of the External Oblique muscle. The fibres from this extensive origin converge, as they pass upward and backward, to form a thick rounded mass, which becomes somewhat twisted on itself as it is inserted into the inferior angle of the scapula. There is no cellular interval between the middle and the lower divisions.

Variations. — The Serratus Magnus frequently possesses nine digitations, which arise from but eight ribs, two slips arising from the second. The number of ribs covered by the muscle may vary from eight to ten. Luschka describes the lower division as overlaid in old subjects with a thin layer of firm aponeurotic tissue.

THE DELTOID.

The Deltoid muscle resembles the Greek letter Δ inverted, the upper border being irregularly concave. It arises from the outer concave portion of the clavicle (anterior or median fibres), from the anterior portion of the acromion (middle fibres), from the greater portion of the under lip of the spine of the scapula, and from the infra-spinous fascia near the axillary border (posterior or lateral fibres). The anterior and posterior fibres pass downward obliquely, the middle vertically, and are inserted at corresponding parts of the deltoid ridge of the humerus.

The median fascicles are closely united with the acromio-clavicular ligament, while they are separated from the greater tuberosity by means of a large bursa.

Use.—The muscle, contracting as a whole, and acting upon its insertion, raises the arm to the horizontal position.

The anterior fibres, when they act alone, raise and

adduct the humerus, and assist when both sets act together in the act of folding the arms. When the arm is raised above the horizontal position, these fibres depress and adduct it. They often act in conjunction with the Coraco-Brachialis. When the anterior fibres are active, the posterior fibres are at rest.—The posterior fibres raise the humerus and abduct it. When the arm is raised above the horizontal position, these fibres depress and draw it backward, a movement aided by the Teres Major and Rhomboideus muscles. The anterior fibres are meanwhile relaxed. —The middle fibres are feebler than either of the preceding. They elevate the humerus in a direct line. They can act either with the anterior or posterior fibres in their respective functions.—The actions of the Deltoid muscle, as above described, are dependent upon apposition of the humeral and scapular articular surfaces through the agency of the Supra-Spinatus muscle. — The Serratus Magnus, the long head of the Triceps, and the middle fibres of the Trapezius fix or limit the motions of the scapula during the action of the Deltoid.

Action upon the line of origin is limited to the posterior fibres, which can aid the lower fibres of the Trapezius in drawing the scapula downward.

Outward rotation of the humerus aids the different movements of the Deltoid.

Nerve and Artery.—The Deltoid is supplied by the circumflex nerve and artery.

The Deltoid muscle is remarkably fasciculated. The fascicles are coarse, and are arranged in the form of narrow wedges, seven in number.—The muscle is of loose texture in the clavicular and middle fasciculi, but is aponeurotic over the posterior portion, where it is continuous with the fascia of the Infra-Spinatus. The fascia is stouter as it passes to the Triceps than as it passes to the Biceps muscle. Posteriorly it lies over the head and shaft of the humerus, a large bursa intervening.—The muscle is liable to undergo atrophy — a change that may follow comparatively trivial injuries. When the muscular wasting is marked, the humerus falls away from the scapula. — Sédillot[1] reports an example of rupture of the Deltoid.—The Deltoid, when relaxed, owing to the entire absence of connection with the humerus above the deltoid ridge, can be so grasped as to raise the body of the muscle well from the humerus.

Variations.—The variations of the Deltoid are arranged in six groups. (1) Those examples showing a tendency to cleavage, by which the scapular portion is distinct from the rest of the muscle. The acromial fibres may pass almost independently to the humerus. (2) Those tending to fusion, by which the clavicular fibres pass to the internal intermuscular septum, and are thence continuous with the Brachialis Anticus. The clavicular fibres may also fuse with the Pectoralis Major, the fibres of insertion of the entire muscle becoming continuous with the Supinator Longus. (3) Those in which accessions may be received from the fascia over the Infra-Spinatus muscle. (4) Those in which contributions may be received from the Trapezius. (5) Those in which the acromial or clavicular portions may be absent.

Relations.—The fibres arising from the spine of the scapula overlap the fibres of the external and the long heads of the Triceps at their upper parts. The inferior median portion is supplied by terminal twigs of the artery lying between the Deltoid and the Pectoralis Major. The proximo-median portion, namely, that part lying over the coracoid process, receives a lateral branch from the same artery.

[1] Mém. et Prix de la Soc. de Méd. de Paris, 1817.

The Muscles of the Shoulder.

The muscles of the shoulder, besides those included in the extrinsic set, embrace—

The Supra-Spinatus.
The Infra-Spinatus.
The Teres Minor.
The Teres Major.
The Subscapularis.

THE SUPRA-SPINATUS.

The Supra-Spinatus muscle arises from two-thirds of the supra-spinous fossa, from the upper surface of the scapular spine for its entire length, and from the under surface of the supra-spinous aponeurosis. The muscle is directed outward, the tendon passing over the base of the coracoid process, and is inserted tendinously into the uppermost facet of the greater tuberosity of the humerus, and by a few fibres into the capsule of the shoulder-joint. The tendon has the dull aspect of ligamentous tissue.

Use.—The Supra-Spinatus muscle can elevate the humerus and carry it forward and inward. It aids in holding the head of the humerus close to the scapula during the action of the other muscles, notably the Deltoid, and rotates the humerus outward. When the Deltoid acts before the Supra-Spinatus, as when the parts are suddenly brought into action, it is apt to dislocate the head of the humerus. The muscle aids supination, and acts with the Teres Minor.

Hamilton[1] mentions an instance of a woman who, after carrying a bundle of hay upon her head for a long way with her arms uplifted, suddenly threw it to the ground, and in so doing dislocated the head of the humerus. In this case it is fair to suppose that the muscles holding the arm up had become fatigued, and were no longer efficient in retaining the head of

[1] Fractures and Dislocations, 534.

the humerus in close contact with the scapula, while the depressor fibres of the Deltoid muscle in lowering the arm were sufficiently strong to throw the head of the humerus out of the glenoid cavity.

Duchenne[1] believes that the Supra-Spinatus muscle, aided by the Serratus Magnus and the superior portion of the Trapezius, can elevate the humerus without the assistance of the Deltoid. In this act the humerus is carried forward and a little outward. This writer states that, in patients suffering from atrophy of the Supra-Spinatus muscle, the Infra-Spinatus and Trapezius muscles, the Teres Major and the long head of the Triceps can dislocate the head of the humerus with ease.

Nerve.—This is derived from the suprascapular.

No important Variations of the muscle are known.

THE INFRA-SPINATUS.

The Infra-Spinatus muscle arises from the infra-spinous fossa of the scapula, from the under surface of the spine, and by a few fibres from the infra-spinous aponeurosis. The tendon passes over the capsule of the shoulder-joint, from which it is occasionally separated by a bursa (bursa of Hagen), and is inserted into the middle facet of the greater tuberosity of the humerus.

Use.—To roll the arm outward, and to draw it down after it has been elevated.

Nerve.—This is derived from the suprascapular.

The muscle derives some support from the fascia passing between its lower border and the Teres Major, and from the long head of the Triceps muscle.

Variations.—The muscle may split into two or three laminæ, of which the middle, when present, has received the name of the Middle Infra-Spinatus muscle.—The Infra-Spinatus may fuse with the Teres Minor, and may send accessions to the Deltoid, or receive slips from that muscle.

THE TERES MINOR.

The Teres Minor is intimately associated with the Infra-Spinatus. It arises from a groove on the dorsum of the scapula at its axillary border, and from the inter-muscular septum between it and the Teres Major muscle, as well as from the inferior part of the infra-spinous aponeurosis. The muscle is directed outward to be inserted tendinously into the lowest facet of the greater tuberosity of the humerus, and, by a few fleshy fibres, upon the adjacent portion of the shaft.

Use.—To assist in outward rotation of the arm.

Nerve.—This is supplied by the circumflex humeri nerve.

Variations of the Teres Minor include fibres of origin from the long head of the Triceps muscle and the fusion of the muscle with the Infra-Spinatus. Rarely it is absent.

THE TERES MAJOR.

The Teres Major muscle arises from the quadrilateral space on the dorsal surface of the scapula near its inferior angle, and from intermuscular septa between it and the adjacent muscles. It passes upward and forward to be inserted by a thin broad tendon into the posterior lip of the bicipital groove, in close proximity with, if not actually attached to, the tendon of the Latissimus Dorsi. A small bursa is usually interposed between the two tendons.

Use.—The Teres Major raises the glenoid angle of the scapula by approximating the inferior angle to the humerus, at the same time drawing the humerus to the chest and rotating it slightly inward. Acting with the Latissimus Dorsi it depresses the elevated humerus.

Nerve.—The nerve is derived from the subscapular.

Variations prove that the Teres Major has close affinities with the Latissimus Dorsi, if it may not be considered the result of cleavage of this muscle. It sometimes fuses with the latter. It may send accessions to the fascia of the arm, or receive them from the Rhomboideus.

THE SUBSCAPULARIS.

The Subscapularis arises from the venter of the scapula throughout its extent, excepting the neck and the margin for the insertion of the Serratus Magnus.

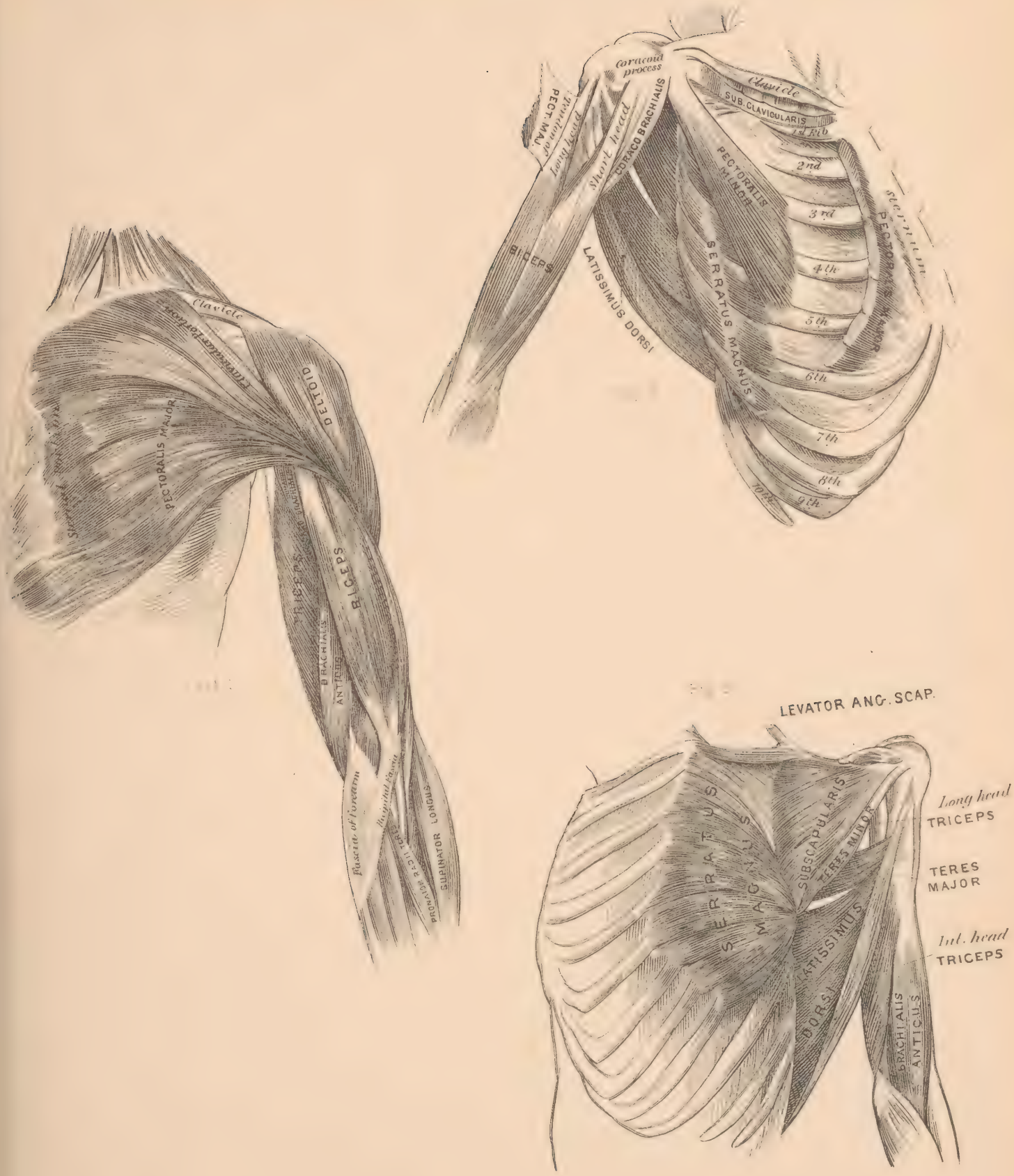
[1] Physiologie des Mouvements, 1878.

EXPLANATION OF PLATE XLVI.

Fig. 1. The superficial muscles of the shoulder and the arm, seen from in front.

Fig. 2. The deep muscles of the shoulder, the arm, and the side of the chest. The position of the subclavius muscle is indicated, but the muscle itself is not figured.

Fig. 3. The deep muscles of the shoulder, the arm, and the chest. The pectoralis major, pectoralis minor, and subclavius muscles have been severed, the clavicle detached from the sternum, and the scapula rotated outward.



T. Sinclair & Son, Lith.

Some fibres also arise from the intermuscular septum between the Teres Major and the long head of the Triceps muscle. The muscle presents a more or less regularly fasciculated appearance, which is due to fibres arising tendinously from the minute ridges of the venter—those from the depressions between them being fleshy. The tendon is broad, and is inserted at the lesser tuberosity and at a slight distance below it on the surgical neck of the humerus. The upper part of the tendon is lost in the capsule of the shoulder-joint.

Use.—The Subscapularis rotates the humerus inward. According to Duchenne, it assists in pronation.

Nerve.—The nerve is derived from the subscapular.

Between the tendon, the neck of the scapula, and the base of the coracoid process, a bursa is seen which communicates with the shoulder-joint, and which is lined with synovial membrane.—Some of the lower fibres of the muscle terminate while still fleshy upon the humerus. Gruber compares this slip to an offshoot like that of the Teres Minor to the Infra-Spinatus muscle.—Henke asserts that the tendon is inserted into the capsule to prevent the nipping of the latter in the motions of the humerus.—The lower fibres of the muscle may be attached in part to a fibrous prolongation that completes the bicipital groove posteriorly.—The fasciculi on the venter are five in number, and present intervals within which are seen five other fasciculi, by the convergence of which the tendon of insertion is formed.

Variations.—The chief variations of the Subscapularis consist of errors in longitudinal cleavage and in an occasional accessory slip passing from the lower border of the scapula to the capsule of the shoulder-joint, or over the capsule to the humerus. Slips may be received from the Pectoralis Major.

The Muscles of the Upper Arm.

The muscles of the upper arm include—

The Coraco-Brachialis.
The Biceps Flexor Cubiti.
The Brachialis Anticus.
The Triceps.
The Anconeus.

THE CORACO-BRACHIALIS.

The Coraco-Brachialis muscle arises tendinously from the tip of the coracoid process of the scapula in common with the short head of the Biceps, and by fleshy fibres from the posterior surface of the tendon of the short head of the same muscle. The muscle is slender and flat, is directed downward and backward to be inserted into the median border of the humerus about on a level with the deltoid ridge, and by a few fibres into the internal intermuscular septum. In muscular subjects the belly of the Coraco-Brachialis can be detected when the forearm is flexed.

Use.—To carry the arm forward and inward, and at the same time to slightly elevate it. It also makes tense the internal intermuscular septum, thus rendering it a fixed surface for the origin of other muscles.

Nerve.—This is derived from the external cutaneous nerve.

A cleft usually exists in the origin and body of this muscle, permitting the escape of the musculo-cutaneous nerve.

Variations.—Among these are to be noticed: (1) The increase of the size of the cleft just mentioned, so that the entire muscle is split into two portions. (2) Rarely, the muscle or the slip to the internal intermuscular septum is absent. (3) The muscle may arise in common with the tendon of insertion of the Pectoralis Minor. (4) It may undergo imperfect planar cleavage, exhibited in short slips passing from the coracoid process to the capsule of the shoulder-joint, or to the neck of the humerus. (5) Probably belonging to the same group are the slips which pass between the tendon of the Subscapularis muscle and the brachial fascia, as well as others which pass from the tendons of the Latissimus Dorsi and Teres Major muscles to the tendon of the Coraco-Brachialis. (6) An accession may pass to the external intermuscular septum.[1]

THE BICEPS FLEXOR CUBITI.

This muscle arises by two heads, as the name expresses, and is inserted into the tuberosity of the radius.

The long or reflected head arises from the edge of the glenoid cavity, penetrates to the interior of the shoulder-joint, and winds over the head of the humerus to enter the bicipital groove, within which it is retained by a number of transverse fibrous bands. It joins the belly of the muscle, just below the inferior border of the Pectoralis Major, about the middle of the arm.—The short head arises by a broad flat tendon from the coracoid process of the scapula. It unites with the main mass at about the same point as the long head. The muscle, thus constituted, presents a conspicuous eminence on the anterior surface of the arm. Its posterior border is flattened, its anterior convex, and just above the elbow it terminates abruptly in a tendon, which is slightly twisted upon itself as it approaches its insertion upon the posterior portion of the tubercle of the radius.

A bursa mucosa is seen surrounding the long tendon of origin, and another beneath the tendon of insertion.

At the insertion of the muscle a slip of fascia (semilunar fascia) is given off from the ulnar border, and is lost upon the fascia of the forearm, which it materially strengthens.

[1] For relations of this muscle to the fascia see account of the fascia of the arm.

Both heads of the muscle are almost entirely tendinous as they lie beneath the Pectoralis Major. The tendon of insertion is robust and rounded on the outer border.

Use.—The arm being pronated, the muscle restores the forearm to supination, and then flexes the radius, and consequently the forearm. Contraction of the Biceps interferes with elevation of the humerus above the horizontal line.

Nerve.—This muscle is supplied by the external cutaneous nerve.

Relations.—The tendons of origin are covered by the Pectoralis Major and the Deltoid muscle. The body of the muscle lies beneath the skin, forming upon contraction a conspicuous mass. Behind are the humerus and the Brachialis Anticus. The external cutaneous nerve lies behind the body, and is held closely thereto, so that the finger thrust between the Biceps and the Brachialis Anticus will displace the nerve forward with the former muscle. The twigs from the brachial artery enter the posterior surface near the inner border.—On the inner side, at the upper third, the muscle lies in contact with the Coraco-Brachialis; at the lower two-thirds, in contact with the brachial artery and the median nerve. — The external cutaneous nerve becomes superficial at the outer border of the tendon of insertion. The Brachialis Anticus is visible here, the Supinator Longus lying just outside of it.

Variations of the Biceps are numerous, but are capable of the following arrangement: (1) Errors of cleavage, by which the muscle may be split in various degrees, either longitudinally, as in the belly, or in planes, as in one or both of the heads. (2) Accessions may be received from both points of origin; from the neck, the bicipital groove, the deltoid ridge, and the external condyloid ridge of the humerus; and from the internal intermuscular septum. These embrace the most frequent variations, and may occur singly, or, in some instances, together. (3) Accessions may be received from the Pectoralis Major, the Coraco-Brachialis, the Brachialis Anticus, the Supinator Longus, and the Pronator Radii Teres. (4) Slips may be sent to the Flexor Carpi Radialis, to the bursa over the tubercle of the radius, to the capsule of the elbow-joint, and to the coronoid process of the ulna. (5) The long head of the muscle, according to H. Welcker,[1] may arise from the bicipital groove. (6) The entire muscle is inserted into the ulna when the radius is absent. (7) The muscle or any of its parts may be absent. Care should be taken not to confound the effects of disease in and about the long tendon with the variations in that portion of the muscle (see group (5) of variations). Chronic rheumatoid arthritis sometimes causes the long head to be absorbed as it passes through the shoulder-joint, when abnormal attachments are in consequence established at the bicipital groove. In place of such disappearance of the long tendon, it may be found atrophied and split up into many fibrils as it passes through the shoulder-joint.—Both heads have been known to rupture, as the result of prolonged and excessive contraction.

[1] Zeit. für Anat. und Entwickelungsgesch., i. 1876, 173, fig.

THE BRACHIALIS ANTICUS.

This muscle arises on either side of the deltoid ridge, and from the anterior surface of the humerus below this point, as well as from the intermuscular septa, notably the external. The muscle passes downward and slightly inward over the anterior surface of the elbow-joint, with which it is intimately connected, and is inserted on the anterior surface of the coronoid process of the ulna.

Use.—To flex the ulna, and consequently the forearm, upon the humerus, and to draw the anterior portion of the capsule of the elbow joint forward during flexion.

Nerve.—The median portion is supplied by the external cutaneous nerve, the lateral portion by the musculo spiral nerve.

Remarks.—The muscle is fleshy at its origin at the inner aspect of the humerus, and tendinous at the outer side, where, for a short distance, it contributes to the formation of the external intermuscular septum, from which some muscular fibres arise. At and below the elbow it is fibrous. The fibres along the inner border of the muscle in part arise from the inner intermuscular septum.

Relations.—In front, the Biceps, the brachial artery and veins, and the median nerve. Behind, the humerus; on the inner side, the internal cutaneous nerve. To the outer side, above, the external head of the Triceps; between the two muscles are the musculo-spiral nerve, and the superior profunda artery and vein; below, the Supinator Longus muscle, with the same structures intervening as above.

Variations of this muscle consist of four kinds: (1) A disposition to cleavage—either longitudinal or planar. In the latter instance the deeper set of fibres may be inserted into the capsule of the elbow-joint. (2) Accessions may be received from the Coraco-Brachialis muscle. (3) Slips may be sent from the muscle to the fascia of the arm or forearm, or to the following muscles: the Supinator Longus, the Pronator Radii Teres, the Biceps, and the Flexor Sublimis Digitorum.

THE TRICEPS.

The Triceps muscle is composed, as the name expresses, of three heads. One of these arises from the axillary border of the scapula; and the remaining two from the posterior surface of the humerus. The part answering to the belly or body of other muscles is imperfectly defined. The muscle is inserted into the ulna at the olecranon.

The *scapular* or *long head* arises by a slender tendon from the axillary margin of the scapula and from the infra-glenoid tubercle. It is in close proximity to the shoulder-joint, and passes downward between the Teres Major and Teres Minor muscles to be inserted on the posterior surface of the aponeurosis of the muscle.

The *external head* arises tendinously from the posterior surface of the neck of the humerus below the great tuberosity, and by fleshy fibres from the posterior surface above the spiral groove and from the external intermuscular septum. Its fibres are inserted into the upper part of the external surface of the aponeurosis. Some of the fibres contribute to form the inner head.

The *internal head* arises from the posterior surface of the humerus below the spiral groove, and from the internal intermuscular septum. Its fibres are inserted on the deep anterior surface of the aponeurosis. Some of the fibres of this head are nearly horizontal.

The fibres of the *aponeurosis* converge a short distance above the elbow-joint to form the tendon, which is thick and massive, and which is inserted into the olecranon at its upper and posterior parts, and into an oblique ridge separating the posterior and external surfaces of the process.

Use.—To extend the ulna, and consequently the forearm. In this act the humeral attachments are chiefly efficient. The long head can fix the shoulder-joint, thus aiding the Supra-Spinatus. It aids feebly in depressing the raised humerus. The long head tends to support the shoulder-joint posteriorly as the long head of the Biceps in a greater degree supports it anteriorly.

Under the name of the Subanconeus, Theile describes a pair of muscular slips, which arise respectively from the epitrochlea and epicondyle, and which are inserted upon the capsule of the elbow-joint.—A fibrous band is described by Holbertsma extending from the scapular head near its origin to the Latissimus Dorsi.

Nerve.—The muscle is supplied by the musculo-spiral nerve.

Variations in the Triceps muscle consist of additional slips of origin from the coracoid process, from the shaft of the humerus, and from the capsule of the shoulder-joint. Both fibrous and muscular accessions may be received from the Latissimus Dorsi, Teres Major, and Anconeus. The fibres of the external head may be continuous with those of the Extensor Carpi Ulnaris—an arrangement constantly seen in some quadrupeds.

THE ANCONEUS.

This muscle appears to be a continuation of the outer head of the Triceps. It is a small slip placed to the outer side of the elbow-joint. Arising from the epicondyle of the humerus, its fibres pass downward in a radiating manner to be inserted into the outer surface of the olecranon, or to extend thence to the upper third of the shaft of the ulna. The upper fibres are nearly horizontal, while the lower fibres are oblique.

Use.—The Anconeus muscle assists the Triceps in extending the forearm.

Nerve.—The muscle receives a branch of the musculo-spiral nerve.

The Variations of the Anconeus consist in fusing with the Triceps, in sending an accession to the Extensor Carpi Ulnaris, in receiving an accession from the Latissimus Dorsi, in splitting into two parts, and in sending a fascicle to bridge the ulnar nerve.

The Pronator and Flexor Muscles of the Forearm.

The Pronator and Flexor muscles of the forearm embrace—

The Pronator Radii Teres.
The Flexor Carpi Radialis.
The Palmaris Longus.
The Flexor Carpi Ulnaris.
The Flexor Sublimis Digitorum.
The Flexor Profundus Digitorum.
The Lumbricales.
The Flexor Longus Pollicis.
The Pronator Quadratus.

THE PRONATOR RADII TERES.

This muscle arises by two heads: one from the anterior surface of the epitrochlea in common with the intermuscular septum separating the Palmaris Longus and the Flexor Sublimis Digitorum, and by a slip from the aponeurosis of the forearm; the other by a slip from the inner aspect of the coronoid process of the ulna. The median nerve passes between the heads. The muscle passes downward and outward, and is inserted into the radius below the oblique line, in close relation to the line of radial origin of the Flexor Sublimis Digitorum.

Its origin is in common with the flexor mass arising for the most part from the septum above described. The insertion is tendinous; the inner border in part is tendinous. The ulnar head is often fleshy, but has been described as tendinous.

Use.—To pronate the radius, and to assist in flexion of the forearm on the arm.

Nerve.—The muscle is supplied by the median nerve.

Relations.—In front of the humeral head lies the integument. The radial artery and nerve cross the muscle near its insertion. The muscle rests upon the Flexor Sublimis Digitorum and the radius. To its inner side lies the Flexor Carpi Radialis. The outer side forms the free edge of the flexor mass, and lies near the Brachialis Anticus.—At the ulnar head, in front, lie the radial artery and nerve. To the outer side is the Supinator Brevis; at the inner border the humeral head of the muscle. In front lies the median nerve, and behind the ulnar artery.

Variations.—The muscle may undergo cleavage in whole or in part. It may receive accessory slips, higher up the humerus, from the Brachialis Anticus and the Biceps muscles. It may be fused with the Flexor Carpi Radialis. The humeral slip may contain a sesamoid bone. The coronoid head may be absent or be duplicated. When the supratrochlear process of the humerus is present, a fibrous band passes thence to the epitrochlea, and from it arise fibres of the Pronator.

THE FLEXOR CARPI RADIALIS.

The Flexor Carpi Radialis arises tendinously from the epitrochlea, and by fleshy fibres from the intermuscular septum and the antebrachial fascia. It passes downward and laterally to become tendinous at the upper third of the forearm. The tendon enters a special sheath in the anterior annular ligament, and passing beneath the ball of the thumb is inserted upon the base of the second metacarpal bone.

Use.—To flex the carpus.

Nerve.—It is supplied by the median nerve.

The tendon embraces the palmar surface of the base of the second metacarpal bone, and gives off expansions to the trapezium.

Relations.—At its origin and throughout its proximal third the muscle forms part of the flexor mass, and lies between the Pronator Radii Teres and the Palmaris Longus. On the lateral border of the tendon lies the radial artery. Behind it is the Flexor Sublimis Digitorum.

Variations.—Slips of origin in excess may arise from the ulna below the coronoid process, from the radius, and from the Biceps muscle. The median nerve may pass between the humeral and ulnar origins. The muscle may fuse with the Pronator Radii Teres. The main tendon may be inserted into the trapezium, the scaphoid bone, the annular ligament, or into the third or the fourth metacarpal bone. A muscle representing a shifted radio-carpal flexor may arise from the radius, and be inserted into the first metacarpal and the trapezoid bones.

THE PALMARIS LONGUS.

This muscle arises from the epitrochlea by a slender tendon and from the intermuscular septa. It passes downward and forward, becomes tendinous at about the lower third of the forearm, and is inserted partly into the palmar fascia and into the fascia over the ball of the thumb (volar aponeurosis), and partly into the annular ligament. Its tendon forms an eminence above the wrist in the undissected subject.

Use.—To make tense the palmar fascia and adjacent parts, and to flex the hand. The action of this muscle may be described as a forerunner of other flexor movements.

Nerve.—It is supplied by the median nerve.

Variations.—The Palmaris Longus, while the most variable of all the muscles, presents but few distinct types of variation. It may be fused with one or more of the flexors of its own group, notably the digital and the carpo-ulnar flexors. It may undergo cleavage so that two or even three muscles exist. It appears to have close affinity with the Abductor Pollicis, since it may send accessions to it or be inserted upon it.—Slips may pass to the Abductor Minimi Digiti.—The muscle may be inserted into the ulna or the carpus; when the latter, it is inserted most frequently into the pisiform bone. It may be absent.—While this muscle is compensatory with the Flexor Carpi Ulnaris, and is held with the latter muscle in the same sheath of the deep fascia, it receives its nerve supply, not from the ulnar, but from the median nerve.

THE FLEXOR CARPI ULNARIS.

This muscle lies in the anterior and in the median part of the forearm, and extends from the epitrochlea of the humerus to the carpus and the metacarpus. Its tendon for a short distance above the wrist forms a conspicuous subrounded eminence in the undissected arm.

It arises from the epitrochlea of the humerus in common with the other superficial flexor muscles, and to a slight extent from the coronoid process of the ulna. It also arises from the posterior border and upper two-thirds of the ulna by a strong aponeurotic expansion. It passes beneath the annular ligament and is inserted into the pisiform and fifth metacarpal bones. A distinct tendinous fascicle extends from the pisiform to the unciform bone. A thin fibrous expansion is lost upon the palmar aponeurosis.

The muscle is tendinous at the inner surface for nearly its entire length. It is slightly fibrous at its origin, while its lateral border is continuous with an aponeurosis which is inserted into the ulna. Some of the fibres of the deep flexor

arise from this aponeurosis. At the upper half the tendon is enveloped by muscular fibres.

Use.—To flex the carpus, and to deflect it from the ulnar side. The statement that this muscle is an adductor of the hand is disputed by Duchenne. In the judgment of this observer, the adduction of the hand is effected by the combined action of the flexors, and is a restrained motion. There is no doubt, however, that in many of the lower animals the muscle is a true adductor.

Nerve.—The muscle is supplied by the median nerve.

Relations.—In front lie the skin and the fascia. Behind it are the border of the ulna and the fascia of the back part of the forearm. The ulnar nerve enters between its two heads, and runs along the entire extent of the muscle. The ulnar artery lies beneath it at the proximal half. The relation of the muscle to the artery is so constant that Cruveilhier calls it the satellite of the artery. A fibrous arch near the origin of the muscle affords room for the passage of the ulnar nerve and of the ulnar recurrent artery.

Between the tendon at the wrist and the pisiform bone a small bursa is exceptionally seen.

Variations.—The muscle may derive a slip from the Triceps, and send slips to the fourth metacarpal bone, to the interosseous, or the annular ligament, and to the muscles of the little finger. It may be compensatory with the Palmaris Longus. On the whole, variations are rare. In the lower animals the muscle frequently receives a slip from the Latissimus Dorsi.

THE FLEXOR SUBLIMIS DIGITORUM.

This, the most powerful of the superficial muscles of the forearm, extends from the epitrochlea of the humerus and passes to the second phalangeal row. It arises from the epitrochlea in common with the other flexor muscles, from the ulna near the coronoid process, from the anterior border of the radius by a thin membrane-like slip, and from the intermuscular septa. The muscle passes down the forearm, and divides into four tendons, each of which passes beneath the annular ligament, and is inserted into the base of the second phalanx of each of the four outer fingers. Each tendon is perforated to permit the transit of the tendon of the Flexor Profundus Digitorum.—As the muscle divides at the base of the first phalanx, two lateral processes of the tendon pass forward again to unite and to be inserted at the sides of the second phalanx. Prior to this division and insertion each tendon is inclosed in a sheath which is fixed to the sides of the phalanx. This sheath is strengthened, in front, by interlacing fibres which have received the name of the *chiasm of Camper*. The tendons themselves are strengthened by small accessory bands termed *vincula accessoria tendinum*, which are connected with the phalanges.

Use.—To flex the second and third rows of the phalanges, and these being flexed, to assist in flexing the first row and the carpus. With the aid of the Lumbricales and the Interossei, the muscle flexes the first phalanx upon the metacarpus. In the action of this muscle the flexion of the second and third phalanges must precede that of the first, a point often overlooked in studying malpositions of the fingers in flexion.[1]

Nerve.—The muscle is supplied by the median nerve.

The fibres arising from the shaft of the radius to the outer side of the Flexor Longus Pollicis form a thin lamelliform slip. The under surface is fibrous proximally where it covers the ulnar nerve.

Of the divisions of the muscle the ulnar is by far the most important. It presents a superficial and a deep set of fascicles. The superficial set is external, receives the radial slip, and yields the portions for the third and fourth fingers. The deep set is internal, and supplies the slips going to the second and fifth fingers. The tendon for the fourth finger is the largest, and that for the fifth the smallest.—The tendons are received within fibrous sheaths at about the lower border of the Pronator Quadratus. They are lined with synovial bursæ, which inconstantly communicate with the sheath of the tendon of the Flexor Longus Pollicis.

Relations.—Above lie the Flexor Carpi Radialis, the Palmaris Longus, and the Pronator Radii Teres. The radial artery runs upon the upper surface near the radius at its upper half and to the inner side at the lower half of the radius. To the outer side lies the Flexor Carpi Ulnaris. Behind the muscle is in contact with the Flexor Profundus Digitorum and the Flexor Longus Pollicis. Lying directly upon the Flexor Profundus Digitorum is the ulnar nerve. The median nerve is generally described as lying between the superficial and the deep flexor, but, more properly, it may be said to lie within the embrace of the superficial flexor.

Remarks.—In contracture of the muscle the fingers can be extended by manipulation, especially if the wrist be previously flexed.—The fibres of the muscle can be lacerated by powerful traction on one or more of the tendons, and under rare conditions a portion of a finger and the entire flexor tendon in connection therewith can be severed from their attachments.[2]

The sheath of the tendon either in the hand or the forearm may be the seat of diseased action. Synovial distension may occur, forming cyst-like collections; or

[1] W. W. Keen, Phila. Med. Times, xii. 1882, 373.

[2] T. Nunnely, Trans. Path. Soc. London, 1860, 199.

an inflammatory excitement may extend up into the forearm, a result frequently seen after amputation of any portion of a finger.

Variations.—The muscle may be fused in part with the Palmaris Longus, the Flexor Profundus Digitorum, or the Flexor Longus Pollicis.—The several slips may be separated by cleavage from one another. The slip to the fifth finger may be separate from the remaining slips.—Inscriptions may exist on one or more of the slips.—Defects are rare, and appear to be confined to the slip to the fifth finger and to the origin of the muscle from the radius. An accessory slip from the Flexor Sublimis Digitorum may rarely join the tendon of the Supinator Longus, or the muscle may itself receive a slip from the Pronator Radii Teres.

In the light of comparative anatomy, the Flexor Sublimis Digitorum is the result of a superficial planal cleavage from the Flexor Profundus Digitorum. In the majority of animals it is the smaller of the two muscles, and is often a mere superficial slip from the deep flexor.

THE FLEXOR PROFUNDUS DIGITORUM.

This muscle is situated beneath the Flexor Sublimis Digitorum to the inner side of the Flexor Longus Pollicis and on the same plane with it. It arises from the depression on the median surface of the olecranon, from the upper two-thirds of the shaft of the ulna, and from the interosseous membrane. It divides unequally at the lower third of the forearm into four tendons. The lateral slip designed for the index finger (Flexor Indicis) soon separates from the remaining three, which continue in close relation until they have passed beneath the annular ligament to the palm, when they diverge to be inserted into the bases of the last phalanges of the second, third, fourth, and fifth fingers. The tendons perforate those of the Flexor Sublimis Digitorum. They lie close to the lateral margin of the pisiform bone, and hold to it a relation similar to that held by the Flexor Longus Pollicis to the trapezium.

Use.—To flex the fingers. The action is checked by fibrous sheaths associated with the tendons as they pass beneath the annular ligament. It acts synergetically during extension of the fingers.

The anterior surface of the lower half of the muscle is occupied by broad tendons, while the upper portion is entirely muscular. A few fibres arise from the aponeurosis of the Flexor Carpi Ulnaris; these fibres are more extensive at the upper part of the ulna than elsewhere.

Relations.—Above it is the Flexor Sublimis Digitorum, and crossing the muscle obliquely is the ulnar artery. At its origin near the coronoid process it is in contact with the Brachialis Anticus. The median nerve is in part in contact with the deep flexor, but its more important relation is with the superficial. Behind are the radius, the ulna, and the interosseous membrane. To the lateral side are the Flexor Longus Pollicis and the radius. Here also are seen the anterior interosseous vessels and nerve. To the median side is the Flexor Carpi Ulnaris, and lying upon this aspect (commonly described as in front of the muscle) are the ulnar nerve and the lower part of the ulnar artery. Behind is the Pronator Quadratus.

Nerve.—The deep Flexor like the Flexor Brevis Pollicis derives its nerves from both the median and the ulnar, the supply for the index slip coming from the former and the supply for the remaining portion from the latter nerve.

For the details of this somewhat complicated muscle the reader is referred to the following:—

The muscle is susceptible of division into a lateral and a median mass, which are more or less distinct and are supplied by different nerves. The lateral longitudinal portion occupies the anterior concave surface of the ulna, and yields the slip for the index finger. It is supplied by a branch of the *median nerve*. The median portion is inclined more obliquely forward and downward, and appropriates to itself a slip from the aponeurosis of the Flexor Carpi Ulnaris. It yields the bellies for the third, fourth, and fifth fingers, and is supplied by a branch of the *ulnar nerve*. The tendons for this portion keep well together to the wrist, while the

EXPLANATION OF PLATE XLVII.

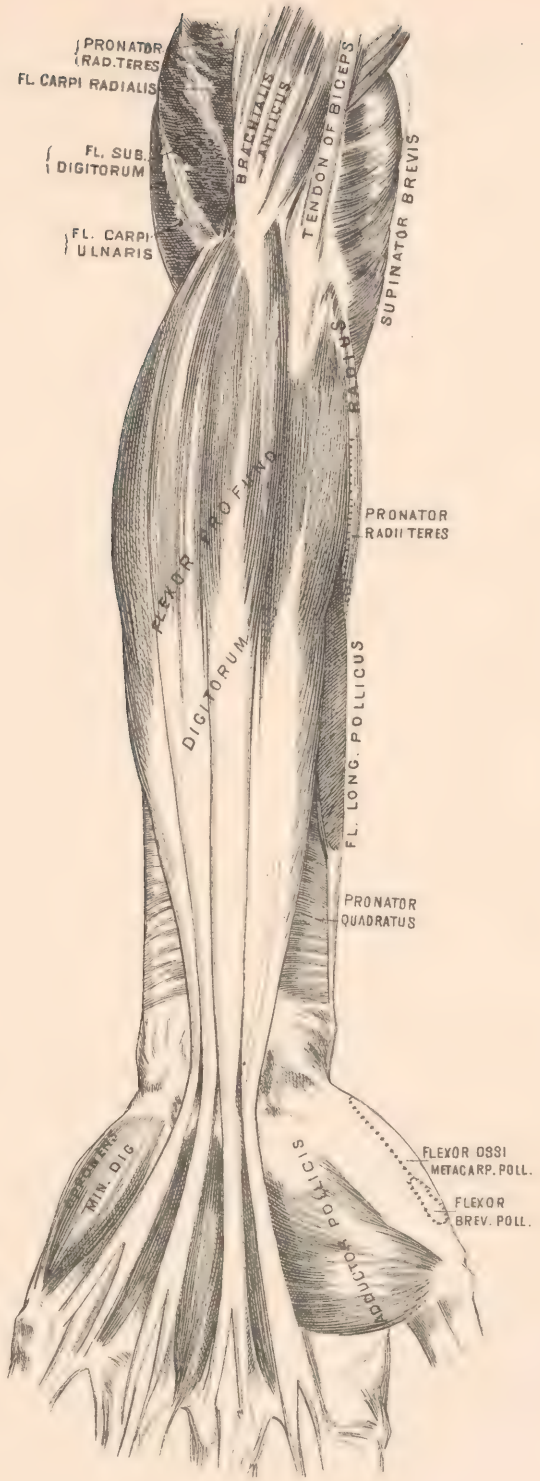
Fig. 1. The superficial muscles of the flexor surface of the forearm, seen from in front. The slender muscle to the median side of the flexor carpi radialis is the palmaris longus. The muscular fibres between the flexor carpi radialis and the supinator longus belong to the flexor sublimis digitorum. The hand is not displayed beyond the metacarpus.

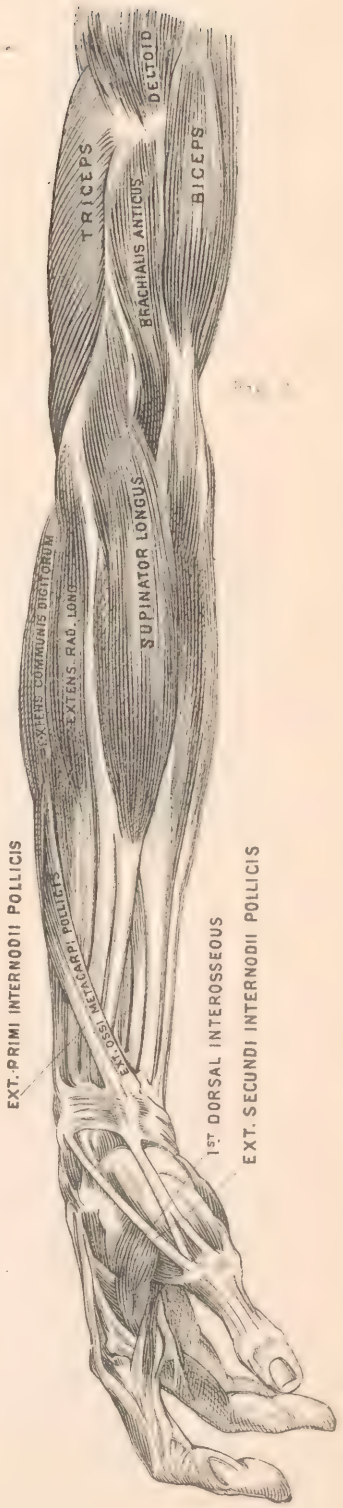
Fig. 2. The deep muscles of the flexor surface of the forearm, showing also some of the muscular attachments of the superficial set, and some of the muscles of the hand. The muscles seen between the palmar tendons of the flexor profundus digitorum are the lumbricales.

Fig. 3. The superficial muscles of the lateral (radial) border of the forearm, including some of the muscles of the arm and the hand.

PLATE XLVII







Hair & Son, Lith.

tendon of the lateral portion is distinct above the wrist. According to Henle, the fourth and fifth slips are united, while the second and third are distinct.

All the tendons pass under the anterior annular ligament and diverge in the palm, each to pierce the corresponding tendon of the Flexor Sublimis Digitorum at the first phalanx of the second, third, fourth, and fifth fingers, and to be finally inserted by a broad tendon on the base of the third phalanx beneath the insertion of the capsule. As the tendon lies in the sheath with the superficial flexor it is marked by a median sulcus which is sufficiently deep to separate the tendon into two bundles. The tendon within the finger is held to the tendon of the superficial flexor and chiasmal fibres at and in advance of the carpo-phalangeal joint by one or more minute, thread-like bands (*vincula*). They are covered with the synovial vascular, villiform processes, and present concave edges. Attached to the tendons of the two Flexors are four remarkable muscles—the Lumbricales (*q.v.*).

Variations of the Flexor Profundus Digitorum embrace a cleavage by which the portion for the index finger is entirely distinct; excess of development, shown in a large surface of origin from the radius and the coronoid process of the ulna; fusion in part with the Flexor Sublimis Digitorum; insignificant variations in the origins of the Lumbricales muscles, and fusion in the forearm of the tendons for the third, the fourth, and the fifth fingers.

THE LUMBRICALES.

The Lumbricales muscles are delicate, fusiform slips, four in number, accessory to the tendons of the Flexor Profundus Digitorum. Each muscle arises from a digital division of the flexor in the neighborhood of the proximal ends of the metacarpal bones, and ending in a tendon is inserted on the dorsal aponeurosis of the fingers in close relationship with the tendons of the Extensor Communis Digitorum and the Dorsal Interossei muscles.

Use.—The Lumbricales extend the last two phalanges, and flex the first phalanx, and in these acts assist the action of the Interossei. The first Lumbrical is a feeble abductor of the first phalanx of the index finger. The function of the Lumbricales persists after the loss of flexion and extension, as seen in some forms of paralysis. They apparently give steadiness to the terminal phalanges at the same time that these distal bones are being acted upon by the tendons of the deep Flexor.

Variations.—The Lumbricales in their variations are seen to become more intimately associated with the Flexors of the fingers, particularly the deep Flexor.

Nerve.—The first and second Lumbricals are supplied by the median nerve; the third and fourth by the ulnar nerve. Thus these accessory slips of the Flexor Profundus Digitorum receive nerve supply from both the median and ulnar nerves as well as the flexor muscle itself.

THE FLEXOR LONGUS POLLICIS

arises from the anterior surface of the radius from the oblique line, as far as the tubercle, to near the upper edge of the insertion of the Pronator Quadratus. It also derives some fibres from the radial half of the interosseous membrane. It becomes tendinous at the lower third of the forearm, the tendon passing beneath the annular ligament, close to the median side of the trapezium, and is inserted into the terminal phalanx of the thumb. Its tendon in the palm closely resembles the index slip from the Flexor Profundus Digitorum. A stout fibrous border runs along the median edge its entire length.

Use.—To flex the thumb. Its tendon moves as over a pulley round the trapezium in the initiation of flexion, the thumb being forcibly extended.

Nerve.—The Flexor Longus Pollicis is supplied by the median nerve.

Relations.—Above it is the Flexor Sublimis Digitorum. Below are the radius and the Pronator Quadratus. To the inner side is the Flexor Profundus Digitorum. In the palm it lies in the large cellular interspace between the two heads of the Flexor Brevis Pollicis, but on the thumb it is confined within a sheath.

Variations.—The muscle may undergo longitudinal cleavage throughout its length. It may receive, commonly, slips from the coronoid process (some writers believe them to be constant), the internal condyle, and the Brachialis Anticus. It may send slips to the first Lumbrical, or to the deep Flexor. It may be absent. A distinct slip may arise at the radius, at the upper margin of the Pronator Quadratus.

THE PRONATOR QUADRATUS.

The Pronator Quadratus is a small square muscle lying at the lower fourth of the forearm beneath all other muscles. It arises from the inner and posterior surface of the ulna at its lower fourth and extends across the interosseous membrane toward the radius, where it is inserted upon its anterior surface and outer edge at the lower fourth of the bone. A thin fibrous expansion is often seen upon the anterior surface. It is more aponeurotic at its origin than at its insertion.

Use.—To pronate the forearm. In this act it is assisted by the Pronator Radii Teres and the Flexor Carpi Radialis. Its connection with the ulno-radial capsule may be of use in withdrawing the anterior wall from the facets during pronation.

Nerve.—The Pronator Quadratus is supplied by the anterior interosseous branch of the median nerve.

Relations.—In front are the deep flexor of the fingers, the long flexor of the thumb, and the Flexor Carpi Ulnaris. Behind are the interosseous membrane, the radius, and the ulna.—The muscle protects the distal ulno-radial articulation.

Variations.—It may be inserted into the annular ligament, or upon the end of the carpus, or it may be absent. Its variations are infrequent. The muscle is slightly tendinous on its anterior surface at the insertion. When carefully dissected it resolves itself into two (or sometimes three) subequal triangular layers. The superficial layer is inserted into the outer and anterior surface of the radius. The deep layer is inserted nearer the wrist, and influences more especially the ulno-radial capsule.

The Supinator and Extensor muscles in the region of the forearm include—

The Supinator Longus.
The Extensor Carpi Radialis Longior.
The Extensor Carpi Radialis Brevior.
The Extensor Communis Digitorum.
The Extensor Minimi Digiti.
The Extensor Carpi Ulnaris.
The Supinator Brevis.
The Extensor Ossis Metacarpi Pollicis.
The Extensor Primi Internodii Pollicis.
The Extensor Secundi Internodii Pollicis.
The Extensor Indicis.

THE SUPINATOR LONGUS.

The Supinator Longus muscle arises from two-thirds of the external condyloid ridge of the humerus at its proximal portion, and is inserted upon the lateral anterior border of the styloid process.

Use.—To flex the forearm. When previous to its action the forearm has been strongly pronated, the muscle supinates it before flexion occurs. It thus complements and assists the action of the Biceps Flexor, the two muscles acting upon separate extremities of the radius. Should the muscle contract while the forearm is supine, semi-pronation results.

Nerve.—The muscle is supplied by a branch of the musculo-spiral nerve.

The tendon extends along the proximal half of the belly, and corresponds nearly to a similar surface on the Extensor Carpi Radialis Longior. It finally is entirely free at about the middle of the forearm. The tendon at the insertion is somewhat expanded, and in part lines the groove on the radius for the Extensor Ossis Metacarpi Pollicis and the Extensor Primi Internodii Pollicis.

Relations.—Above the elbow they are as follows: It overlies the outer half of the Brachialis Anticus muscle; it is overlaid by a small portion of the Extensor Carpi Radialis Longior, and the intermuscular septum between it and the Triceps muscle. The musculo-spiral nerve lies above the elbow between it and the Brachialis Anticus, and in the forearm to its outer side. Below the elbow the muscle covers the Extensor Carpi Radialis Longior at its outer half; it covers the radial artery and vein along its median half. To the median side of its tendon lies the radial artery, to its outer side beneath the deep fascia is the radial nerve, and upon the deep fascia the anterior branch of the external cutaneous nerve.

In the Variations of the muscle there may be found a slip in common with the Extensor Carpi Radialis Longior. Its insertion may extend to the carpus, or to the third metacarpal bone. It may undergo partial cleavage. It may fuse in part with the Brachialis Anticus and the Deltoid muscles.

The Supinator Longus and the Flexor Carpi Ulnaris resemble one another in the following respects: both in part overlie the other muscles of the anterior aspect of the forearm, and both suggest close relationship with the extrinsic muscles, the Supinator Longus with the Deltoid, and the Flexor Carpi Ulnaris with the Latissimus Dorsi.

After the removal of the Supinator Longus muscle the remaining muscles of the anterior aspect of the forearm lie upon the same plane, the Flexor Carpi Ulnaris and Pronator Quadratus excepted.

THE EXTENSOR CARPI RADIALIS LONGIOR.

This muscle arises from the distal part of the external condyloid ridge and the intermuscular septum between it and the Extensor Carpi Radialis Brevior, as well as from the fascia of the forearm. The broad ribbon-shaped tendon becomes cord-like a short distance above the wrist, and is inserted upon the proximal end (base) of the dorsum of the second metacarpal bone.

Use.—To extend the carpus and incline it laterally. When the muscle is atrophied the hand is extended and adducted. Its tendon supports the joint between the trapezoid and the trapezium.

Nerve.—The muscle is supplied by a branch of the musculo-spiral.

The tendon at the belly is exposed for a short distance on the under surface.

Relations.—The muscle lies in part between the Supinator Longus anteriorly and the Extensor Carpi Radialis Brevior posteriorly, but the greater portion of the belly is subcutaneous. Behind it also lie the epicondyle in part, the head of the radius, and the Supinator Brevis. Laterally lie the Triceps and the Extensor Communis Digitorum. The tendon and the Extensor Carpi Radialis Brevior are embraced

by the same sheath, and lie in the outer of two grooves at the distal end of the dorsal aspect of the radius; and, together with the Supinator Longus and lesser radial extensor are crossed at an acute angle by the Extensor Ossis Metacarpi Pollicis and the Extensor Primi Internodii Pollicis. A bursa is seen beneath its insertion upon the second metacarpal bone.

Variations.—Among the variations of the muscle may be mentioned its fusion with the short radial extensor, or the reception of a slip from that muscle.[1] It may undergo partial cleavage, by which the tendon is duplicated.

THE EXTENSOR CARPI RADIALIS BREVIOR.

This muscle arises tendinously from the rough triangular space at the distal end of the epicondyle of the humerus, and by fleshy fibres from an intermuscular septum between it and the Extensor Communis Digitorum. The muscle passes downward to terminate in a tendon which widens slightly to be inserted on the dorsal aspect of the proximal ends of the second and the third metacarpal bones, a thin fibrous expansion being sent to the dorsum of the fourth.

Use.—To directly extend the carpus and incline it laterally.

Nerve.—The muscle is supplied by a branch of the musculo-spiral.

The muscle is tendinous at the distal half anteriorly, and at the proximal half posteriorly. The tendon grooves the pyramidal projection of the proximal end of the metacarpal bone in such a manner as to support the articulation of this bone with the trapezoid and the os magnum.

Relations.—In front, on the lateral border of the muscle, lie the Extensor Carpi Radialis Longior, and in part distally the Supinator Longus. On the median border, *i. e.*, along the line of the radius, the Supinator Brevis, the radial border of the Pronator Radii Teres, and the radial nerve. To the dorsal aspect is the Extensor Communis Digitorum. —The muscle last named is directly continuous with the Extensor, as the two muscles lie in contact with the Supinator Brevis.

A bursa commonly lies between the muscle and the Supinator Brevis, and another between the tendon and the joint uniting the second and third metacarpal bones. — The belly, above, apparently forms a continuation with the Supinator Longus.—An extension of the thin *fascia* from this muscle passes inward, covering in the upper portion of the Supinator Brevis, and is continuous in front of the elbow-joint, where it is lost in the capsule.

Variations.—The muscle presents but few variations. It may undergo longitudinal cleavage, and have as many as three tendons of insertion; the supernumerary slips may pass to the second and third metacarpal bones. It may be absent. Its origin may be intimately associated with the external lateral ligament of the elbow-joint.

THE EXTENSOR COMMUNIS DIGITORUM.

The Extensor Communis Digitorum muscle arises tendinously from the epicondyle of the humerus in common with other extensor muscles, and from the deep fascia of the forearm; also from an intermuscular septum between it and the Extensor Carpi Radialis Brevior, on the radial side, and another between it and the Extensor Minimi Digiti on the ulnar side. The muscle divides a short distance below the middle of the forearm into four tendons, which pass beneath the annular ligament, inclosed in a common synovial sheath (in common also with the Extensor Indicis), and are inserted into the backs of the phalanges of the four outer fingers. The tendons of the second, third, and fourth fingers are connected by flattened bands. A special union exists between the tendon of the fourth finger and that of the Extensor Minimi Digiti.

Use.—To extend the fingers, notably the third phalanx on the second, and to aid in the lateral motions of the fingers. The extension of the first phalanges places the second and third phalanges in a favorable position for apposition of the finger tips with the extremity of the thumb.

Nerve.—The muscle is supplied by a branch of the musculo-spiral.

One or more minute fibrous bands, called *vincula*, pass between each tendon and the phalanges.—The muscle is thin and tendinous at its origin.—The tendon for the third finger is the most powerful.

Relations.—The muscle is free upon the posterior surface of the forearm. Beneath it lie the Supinator Brevis, the extensors of the thumb, and the Extensor Indicis. To the lateral side, above, is the Extensor Carpi Radialis Brevior; below, are the Extensor Carpi Radialis Longior and the extensors of the thumb. To the median side is the Extensor Minimi Digiti.

The tendons are arranged in pairs at the annular ligament, the two central tendons, and the slips for the fourth and fifth fingers remaining together. The outer fasciculus, lower down, is placed in front of the middle fasciculus. The external and internal tendons answer to the interosseous spaces, which they cross obliquely in order to assume a position behind the head of the metacarpal bones to which they belong. The manner of insertion of each tendon on the phalanges is as follows: The tendon, as it passes the meta-

[1] Welcker (Zeitschr. für Anat. und Entwickelungsgesch., 1876, 173) proposes to call all slips of muscular fibre passing between two muscles of the same group *conjugate fasciculi*, since they seem to yoke or bind the two muscles. Conjugate fascicles indicate that the process of differentiation of two muscles from a generalized ancestor has been imperfectly accomplished. They will sometimes be found present in a muscle like the Semimembranosus of the raccoon, when the two main bundles united by them are not separately named.

carpo-phalangeal articulation, is inserted into the base of the first phalanx. Beyond the metacarpo-phalangeal articulation the tendon divides into three fasciculi, two lateral and one central. The former, more robust, embrace the first phalangeal articulation to unite at the proximal extremity of the terminal phalanx. The middle fasciculus is inserted on the base of the second phalanx, and receives accessions from the tendons of the Lumbricales and the Interossei, which converge from both borders of the fingers beneath the lateral fasciculi, *i. e.*, between them and the bones, and are inserted into the central tendon. The membrane formed by these agencies is called "the dorsal aponeurosis."

Variations.—The variations of this muscle embrace the following: (1) A tendency to excess in the tendons of insertion. This is most frequently witnessed in the tendons of the second and third fingers, but may occur in all. (2) A tendency to longitudinal cleavage, by which each of the fingers may be extended by a separate muscle. (3) The muscle may fuse with the Extensor Indicis and the Extensor Secundus Internodii Pollicis, and send slips to the Extensor Carpi Ulnaris and Extensor Minimi Digiti. (4) The tendons of the second and fifth fingers may be absent.

THE EXTENSOR MINIMI DIGITI

arises by a thin tendon in common with the Extensor Communis Digitorum, from the external condyle of the humerus and the fascia of the forearm. It also arises from the ulna by a coarse thin tendon between the Anconeus and the Supinator Brevis, and from the septa between the muscle and the Extensor Communis Digitorum and the Extensor Carpi Ulnaris. It rests upon the Supinator Brevis. When isolated from its relations, it presents a coarse fibrous appearance at the sides. A short distance above the wrist the muscle forms a tendon, which passes through a distinct fibrous canal behind the radio-carpal articulation, and, joining the fourth tendon of the common extensor, is inserted into the base of the first phalanx of the little finger.

Nerve.—The muscle is supplied by a branch of the musculo-spiral nerve.

Use.—To extend the first phalanx of the fifth finger and, according to Duchenne, to adduct it.

Variations.—This is an exceedingly variable muscle. It may be wanting. It often forms two tendons, which subsequently reunite; or, remaining separate, pass to the fourth and fifth fingers. The tendon may split just below the annular ligament into two, which subsequently unite at the base of the fifth finger, or the cleavage may be complete. The radial slip may join a tendinous slip from the Extensor Communis Digitorum. Thus the muscle cannot extend the fifth finger entirely without assistance from the Extensor Communis Digitorum.

THE EXTENSOR CARPI ULNARIS

arises by a thin slip from the epicondyle of the humerus, from the aponeurosis of the forearm, from the septum between it and the Extensor Minimi Digiti, and from the shaft of the ulna as far as its middle third. The muscle inclines somewhat to the ulnar side of the forearm, and ends in a tendon which is free at the inferior third of the forearm. This tendon runs within a deep groove upon the posterior surface of the ulna between the articular surface and the styloid process, and is inserted into the base of the fifth metacarpal bone.

Its superficial surface is conspicuously occupied by an aponeurotic membrane nearly its entire length. The lower third of its deep surface is tendinous. The tendon is stouter than any of the tendons of the common extensor.

Use.—To extend the carpus as well as to elevate and adduct the hand.

Nerve.—The muscle is supplied by a branch of the musculo-spiral nerve.

Relations.—The lower portion of the belly and the tendon lie loosely secured in a sheath; the anterior wall being the ulna, while the posterior wall is united to the ulna by fibrous tissue. At the wrist the tendon is in common or nearly so with the tendon of the Extensor Minimi Digiti. In the forearm the two muscles are separated by a septum. Beneath the upper end of the muscle a bursa is occasionally seen (Meckel).—According to Luschka the Extensor Carpi Ulnaris is analogous to the slip in the leg, which joins the Extensor Minimi Digiti to the Peroneus Brevis.

The muscle is covered by integument above; it lies upon the convergent surfaces of the Anconeus, and Extensor Communis Digitorum above, to which it is slightly attached. Below it rests upon the ulna, the fibres of origin of the Extensor Secundi Internodii Pollicis and those of the Extensor Indicis. To its radial side lies the Extensor Communis Digitorum; to its inner the Supinator Brevis above, and the Flexor Carpi Ulnaris below.

The Variations are, as a rule, infrequent. It is compensatory with the Extensor Minimi Digiti. It receives an accession from the Triceps. Its tendon furnishes a surface of origin for the Abductor Minimi Digiti. It may send accessions to the fascia of the dorsum of the hand, especially along the median border of the fifth metacarpal bone, and to the dorsal aponeurosis of the fifth finger. Some writers believe these fibres to be constant.

THE SUPINATOR BREVIS.

This muscle arises from the external lateral ligament of the elbow-joint, from the orbicular ligament, from the posterior border of the shaft and a depression

beneath the lesser sigmoid notch of the ulna, and from the deep fascia. The muscle passes obliquely downward and inward, closely following the radius, to be inserted into the oblique line, and into the neck of that bone.

Use.—To supinate the radius and directly antagonize the Pronator Radii Teres.

Nerve.—The muscle is supplied by a branch of the posterior interosseous.

The muscle is single at its origin, but soon becomes bilaminate. The superficial lamina forms the greater portion of the muscle. It is composed of longer and more oblique fibres, and contains on the surface a few coarse tendinous slips. It is pierced by twigs of the posterior interosseous artery. The deep lamina is situated near the head, is almost entirely muscular, and contains proximally some horizontal fibres. The posterior interosseous nerve lies in the interlaminate space, and in dissection is lifted up with the superficial lamina.—A few tendinous slips descend vertically on the muscle from the epicondyle.

Relations.—Anteriorly lie the bellies of the Extensores Carpi Radiales Longior and Brevior, and the radial artery. Posteriorly are the elbow-joint and the radius. Directly upon its distal border is the tendon of insertion of the Pronator Radii Teres. Laterally lies the Extensor Communis Digitorum.—A bursa lies between it and the Extensor Carpi Radialis Brevior.

Variations.—It may contribute slips to the Biceps and the Pronator Radii Teres.

THE EXTENSOR OSSIS METACARPI POLLICIS.

This muscle arises from the elongated depression on the posterior surface of the ulna below the origin of the Supinator Brevis, from the interosseous membrane, from the middle third of the posterior surface of the radius, and from a septum between the muscle and the Flexor Longus Pollicis. It is inserted upon the posterior aspect of an aponeurosis which becomes condensed into a flat tendon, turning obliquely round the radial border of the forearm (over the tendons of the Supinator Longus and of the extensors of the carpus), and, passing along the lateral groove at the distal end of the radius in company with the tendon of the Extensor Primi Internodii Pollicis, ends on the radial border of the distal end of the first metacarpal bone.

Use.—To move the first metacarpal bone outward and forward. Albinus (and, following this authority, Continental writers) named the muscle Abductor Longus Pollicis from the fact that the thumb under its contraction is drawn away from the axis of the hand, the muscle in this respect acting in common with the Abductor Pollicis. The two muscles are often more or less fused (see Variations).

Nerve.—It is supplied by a branch of the posterior interosseous.

The groove containing the tendon is converted into a canal by a stout prolongation of the posterior annular ligament. A bursa lies between the tendon and the radial extensors.

Variations.—The muscle is often fused in part with the Abductor Pollicis. It frequently undergoes partial longitudinal cleavage; one tendon passing to the metacarpal bone, and the other joining the Opponens Pollicis. It may be inserted in part upon the trapezium. In some mammals, with a rudimentary first metacarpal bone, it may pass entirely to the carpus.—It was thought best in the text to follow the description usually given by writers respecting the tendon of this muscle. It is probable that more than a single tendon will be found present in the majority of instances.

THE EXTENSOR PRIMI INTERNODII POLLICIS.

This muscle is much smaller than the preceding. It arises from the radius and the interosseous membrane near the middle of the forearm. The tendon accompanies the Extensor Ossis Metacarpi Pollicis, and is received within the same groove on the posterior surface of the radius. It passes downward on the lateral aspect of the carpus, and is inserted by a thin tendon on the aponeurosis of the dorsal surface of the first phalanx of the thumb.

Use.—To extend the first phalanx upon the first metacarpal bone. When this act is complete, the muscle can abduct the thumb.

The Extensor Ossis Metacarpi Pollicis and the Extensor Primi Internodii Pollicis act on the thumb in the line of the radius, the stout prolongation of the posterior annular ligament acting as a pulley to the tendon.

Nerve.—It is supplied by a branch of the posterior Interosseous.

Relations.—The muscle lies to the ulnar side of the Extensor Ossis Metacarpi Pollicis.

Variations.—The muscle is an inconstant one, being found in about five per cent. of subjects. It is peculiar to man. The tendon may be continuous in part with the Abductor Pollicis or the Extensor Ossis Metacarpi Pollicis. A tendinous slip may pass to the base of the first metacarpal bone.

THE EXTENSOR SECUNDI INTERNODII POLLICIS.

This muscle arises from the crest and the posterior surface of the middle third of the ulna, and from the distal portion of the interosseous membrane. The tendon crosses obliquely the sheaths of the extensors of the carpus. It is free directly above the annular ligament, and enters a narrow oblique groove on the posterior surface of the end of the radius to be in-

serted on the base of the second phalanx. The tendon is inclosed in a distinct sheath.

Use.—To extend the terminal phalanx, and indirectly the entire thumb.

The muscle may be regarded as a differentiation from the Extensor Communis Digitorum, and is to the thumb what the Extensor Indicis is to the index finger. Hence its isolation from the Extensor Ossis Metacarpi Pollicis and the Extensor Primi Internodii Pollicis.—A number of tendinous slips of origin are often noticed which have not been included in the description.—The tendon lies halfway within the muscle.

Relations.—The muscle lies beneath the Extensor Communis Digitorum. Beneath it lie the interosseous membrane and the ulna. To the radial side are the Extensor Ossis Metacarpi Pollicis and Extensor Carpi Radialis; to the ulnar side the Extensor Indicis and Extensor Carpi Radialis Brevior. The tendon crosses the sheath of the tendon of the Extensor Carpi Radialis Longior over the first interosseous space to gain the median edge of the first metacarpal bone.

Variations.—The muscle may undergo entire cleavage, or develop more than one tendon. The insertion may advance along the thumb. It may partially fuse with the Abductor Pollicis.

THE EXTENSOR INDICIS.

This muscle arises from about the lower third of the posterior surface of the ulna and from the interosseous ligament, and is inserted on the last two phalanges of the second finger. The tendon enters the sheath of the Extensor Communis Digitorum as far as the carpus.

Use.—To extend the second finger at the first phalanx. It may, in this connection, act conjointly with the Extensor Communis Digitorum. Duchenne detected a slight abducting power in the muscle when faradized.

Nerve.—It is supplied by a branch of the posterior interosseous.

The posterior surface of this muscle, as it lies beneath the fibrous surface of the Extensor Carpi Ulnaris, is distinctly fibrous. This layer is continuous with the intermuscular septum to the outer side of the Extensor Communis Digitorum.

Relations.—Above it lies the Extensor Carpi Ulnaris; below, the muscle rests upon the interosseous membrane. To the radial side lies the Extensor Secundi Internodii Pollicis, and to the outer side, the ulna.—The tendon crosses the carpus and the second interosseous space obliquely, and lies to the median side of the tendon given off to the index finger by the Extensor Communis Digitorum.

Variations of this muscle embrace the following:—

(1) Errors by excess, by which the third and fourth fingers receive tendons. (2) Excess of cleavage, by which the belly may be divided throughout, or the tendons be duplicated. (3) Accessions, received from the Extensor Communis Digitorum. (4) Errors by defect, by which the muscle arising from the radius, may be inserted on the fascia of the hand, or may be absent.

THE MUSCLES OF THE HAND.

The muscles of the hand include those of the—

- Palm.
  - The Palmaris Brevis.
- Thumb.
  - The Abductor Pollicis.
  - The Opponens Pollicis.
  - The Flexor Brevis Pollicis.
  - The Adductor Pollicis.
- Fifth Finger.
  - The Abductor Minimi Digiti.
  - The Flexor Brevis Minimi Digiti.
  - The Opponens Minimi Digiti.
- Interossei.
  - The Dorsal Interossei.
  - The Palmar Interossei.

THE PALMARIS BREVIS.

The Palmaris Brevis is a small muscle of a quadrilateral form. It arises from the ulnar margin of the palmar fascia and the annular ligament, and is inserted upon the skin toward the ulnar border of the palm.

Use.—To assist in deepening the palm in the act of opposing the first and fifth fingers. Duchenne assigns to it a function of flexing the hand, and believes it to be second only in importance in this act to the Palmaris Longus.

Nerve.—The muscle is supplied by the ulnar nerve, a number of branches commonly underlying it.

Variations.—Commonly inconspicuous, it is rarely absent. The numerous reported instances of its absence are thought by Macalister to be errors in observation. It may secure attachment from the pisiform bone, and is of unusual size when the Palmaris Longus is absent. Some fibres may reach the hypothenar eminence.

THE ABDUCTOR POLLICIS.

This muscle arises from the trapezium and the annular ligament. It is a flat muscle forming the greater part of the superficies of the ball of the thumb. The fibres pass downward and outward and are inserted by a broad thin tendon on the lateral border of the first phalanx of the thumb near the dorsum, and are in part continuous with the expansion of the dorsal aponeurosis.

Use.—To abduct the thumb. It is assisted in this act by the superficial head of the Flexor Brevis Pollicis and the Opponens Pollicis.

Relations.—A very narrow cellular line separates it on the median side from the superficial head of the Flexor Brevis Pollicis, which is situated on the same plane. It covers the Opponens Pollicis, from which it can be distinguished by the direction of its fibres, and by a thin intervening aponeurosis.

Variations.—The muscle may undergo longitudinal cleavage. It frequently receives a fibrous slip from the Extensor Ossis Metacarpi Pollicis, and a muscular slip from the styloid process of the radius. A slip may be inserted into the skin. The trapezoid fibres may be absent.

The subcutaneous section of the tendon of this muscle should be essayed, according to Holden,[1] at a point one inch above its insertion.

THE OPPONENS POLLICIS.

The Opponens Pollicis muscle (Flexor Ossis Metacarpi Pollicis) arises from the anterior annular ligament in front of the Flexor Carpi Radialis and Palmaris Longus muscles, as well as from the ridge of the trapezium. The muscle is directed outward and is inserted for the most part by fleshy fibres, along the entire extent of the lateral border of the first metacarpal bone.

Use.—To flex and abduct the first metacarpal bone. The term *Opponens*[2] has been given this muscle, and the Opponens Minimi Digiti under the supposition that these are the chief muscles engaged in *opposing* the first and fifth metacarpal bones. It is inaccurate to confine the term to the Opponens Pollicis, since its action in this regard cannot be separated from that of the Abductor Pollicis and the deep head of the Flexor Brevis Pollicis.

THE FLEXOR BREVIS POLLICIS.

The Flexor Brevis Pollicis muscle is composed of two portions, a superficial and a deep. The *superficial portion* arises by fleshy and tendinous fibres from the annular ligament. The *deep portion* arises from the trapezium and os magnum, from the sheath of the Flexor Carpi Radialis, and from the proximal ends of the second and third metacarpal bones. The deep narrow interspace between the heads is occupied by the tendon of the Flexor Longus Pollicis. The two portions are commonly united by a conjugate fascicle, but each division is inserted separately upon the proximal end of the first phalanx of the thumb, the superficial portion to the lateral and the deep to the median side. A sesamoid bone lies within each tendon.

Use.—To flex and abduct the first phalanx of the thumb.

Nerve.—The superficial portion is supplied by the median and the deep portion by the ulnar nerve.

The superficial portion is thus a member of the abductor set of muscles (including the Extensor Ossis Metacarpi Pollicis, Abductor Pollicis, and Opponens Pollicis) with which it is in intimate association. The deep portion is a true adductor, and is to be studied in connection with the Adductor Pollicis. This fact has long been insisted upon by French anatomists, and has received endorsement from Duchenne in his studies of the electrization of muscles in the living subject.—Hyrtl's statement that the muscle is analogous to the Flexor Sublimis Digitorum—the long flexor being analogous to the Flexor Profundus Digitorum—cannot be sustained.

Relations.—The superficial portion is on a level with the Opponens Pollicis, while the deep is on a level with the Adductor Pollicis. The former overlaps the Adductor Pollicis at the lateral edge. The branches of the median nerve for the thumb cross it.

Variations.—The superficial portion at its origin is in part united with the Opponens Pollicis. It may fuse with the Abductor Pollicis. The entire muscle may be absent.

Remarks.—The mechanism of backward dislocation of the first phalanx of the thumb has been carefully studied by Fabbri,[1] and, since it brings into play anatomical peculiarities of the short flexor of the thumb, may be here described:—

"The first phalanx, as it moves backward, takes with it the two heads of the Flexor Brevis Pollicis, and the sesamoid bone developed in them; the anterior and the lateral ligaments of the joint are torn off from the head of the metacarpal bone, which tears a way for itself through the fibrous tissue uniting the two heads of the Flexor Brevis, between which it projects as a button does out of a buttonhole."

THE ADDUCTOR POLLICIS.

This irregularly triangular muscle arises from the anterior two-thirds of the palmar surface of the metacarpal bone of the middle finger, and by a fasciculus from the anterior part of the carpus. The fibres from this extensive origin converge outward to form a short tendon to be inserted with the deep head of the Flexor Brevis Pollicis through the medium of the sesamoid bone into the base of the first phalanx of the

[1] Landmarks, 103.

[2] It has become customary for anatomists to name any group of muscular fibres intrinsic to the hand or foot, and which may be inserted upon the palmar or plantar surfaces of the metacarpal or metatarsal bones, an *Opponens*, entirely irrespective of function.

[1] Memoire dell' Accad. delle Scienze dell' Instituto di Bologna, vol. x. See also T. Holmes, Surgery, 286.

thumb, and on the capsule of the metacarpo-phalangeal articulation.

Use.—When the thumb is flexed on the carpus the muscle is an extensor; when the thumb is abducted it acts as a flexor and draws the thumb forward and inward; or it may adduct the thumb. It commonly acts in conjunction with the deep head of the Flexor Brevis Pollicis.

Nerve.—The muscle is supplied by the ulnar nerve.

Relations.—Above it lie the flexor tendons of the index finger, with the first lumbrical muscle, the deep head of the short flexor, and the branches of the median nerve to the thumb. Behind it lie the deep palmar arch, and the first dorsal interosseous muscle.

Variations.—The carpal origin may be attached to the trapezium, to the os magnum, and to a fibrous arch extending from the trapezium to the base of the first phalanx. The metacarpal origin may include fasciculi from the fourth and fifth metacarpal bones.

THE ABDUCTOR MINIMI DIGITI.

This muscle arises from the distal half of the pisiform bone, and from the termination of the tendon of the Flexor Carpi Ulnaris. It is inserted on the ulnar border of the first phalanx of the little finger, a slip passing to the dorsal aponeurosis.

Use.—To abduct the little finger from the axis of the hand.

Nerve.—It is supplied by the ulnar nerve either from the deep or the superficial palmar branch.

Variations.—The muscle may have an origin from the ulna. All slips of origin may be absent, save that from the pisiform bone. The muscle may be absent. A muscle described by Gruber, extending from the hamular process of the unciform bone to the pisiform bone, is probably the result of cleavage of the above muscle. It may fuse in part with the Opponens Minimi Digiti. It may arise bipenniform from the inferior third of the lateral margin of the ulna, and, passing beneath the annular ligament, lie to the lateral side of the Adductor of the same finger, and have an insertion in common with it (Günther).

THE FLEXOR BREVIS MINIMI DIGITI.

This narrow muscular slip arises from the ulnar side of the uncinate process of the unciform bone, and from the annular ligament. Its fibres pass forward to be inserted at the base of the first phalanx of the little finger. To its radial side lies the superficial branch of the ulnar artery.

Use.—To flex the little finger.

Nerve.—The nerve is derived from the ulnar.

Variations.—The muscle may receive an accession from the Palmaris Longus. It may have no origin from the annular ligament. It may be fused with the Abductor Minimi Digiti.

THE OPPONENS MINIMI DIGITI.

The Opponens Minimi Digiti muscle arises from the uncinate process of the unciform bone and from the annular ligament. It is inserted along the entire ulnar border of the fifth metacarpal bone.

Use.—To draw the fifth metacarpal bone forward and toward the median line of the palm. This movement is sometimes spoken of as one of abduction since the little finger is drawn away from the fourth.

Nerve.—The nerve is derived from the ulnar.

The muscle is slightly tendinous at both origin and insertion. It lies beneath both the preceding muscles.

Variations.—The muscle may be fused with the Abductor Minimi Digiti. It may undergo entire cleavage. It may be absent.

THE DORSAL INTEROSSEI.

The Dorsal Interossei muscles are four in number. They are best seen from above, where the dorsal surfaces occupy the interosseous spaces on a level with the plane of the back of the metacarpus. Each muscle is bifid at the proximal end, the main portion arising from the metacarpal bone corresponding to the phalanx on which it acts. The short tendon is in each instance inserted into the border of the base of the first phalanx, and, also, by a fibrous sheet, into the delicate dorsal aponeurosis.

Use.—The Dorsal Interossei are all abductor muscles. The first of the series constitutes the fleshy mass that can be felt in the hand between the first and second fingers.

The following includes the description of each of the four muscles:—

The first muscle is the largest. Its first head—the outer and larger—arises from the upper half of the median border of the first metacarpal bone; the second from the entire length of the lateral surface of the second. The tendon joins the extensor of the index finger on its lateral aspect.—The radial artery descends to the palm between the two heads of this muscle. A bursa is described by Synnestedt as lying beneath the tendon.

The second muscle arises by its first head from the ulnar border of the second metacarpal bone, and by its second from the radial border of the third. Its tendon joins the lateral border of the extensor tendon of the middle finger.

The third muscle arises by its first head from the ulnar border of the third metacarpal bone, and by its second from the lateral border of the fourth metacarpal. Its tendon is inserted on the lateral border of the extensor tendon.

The fourth muscle arises by its first head from the median border of the fourth metacarpal bone, and by the second from the lateral border of the fifth metacarpal bone. Its tendon is inserted on the median border of the ring finger.

The fasciculi of each muscle arise from either side of the ridge marking the second and the third metacarpal bone, as well as from the lateral side of the fifth metacarpal bone and the median side of the corresponding bone of the thumb.

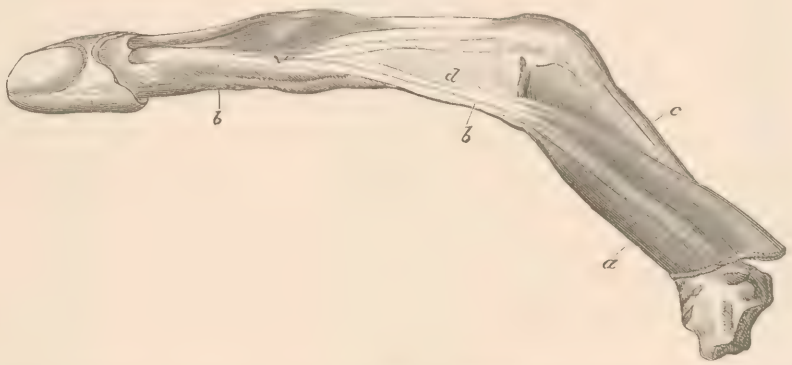
THE PALMAR INTEROSSEI.

The Palmar Interossei muscles are three in number and are situated on the palmar aspect of the metacarpus. Each muscle is short and prismatic, and pursues a course parallel with the axis of the hand to terminate in a small tendon which is inserted on the base of the first phalanx, and on the dorsal aponeurosis of the finger from whose metacarpal bone the muscle arises.

The first muscle arises from the median side of the second metacarpal bone. The second and third muscles arise from the lateral side of the fourth and the fifth metacarpal bone respectively. The third finger is thus free from palmar attachments.

Use.—To adduct the fingers, and, with the Lumbricales, to assist in extending the second and third phalanges of the fingers. The dorsal Interossei abduct the second, third, and fourth fingers. The Palmar Interossei adduct the second, fourth, and fifth fingers. These muscles, when powerfully excited by an electrical current, flex the first phalanx of each finger on the corresponding metacarpal bone, and, by means of the slips passing to the dorsal aponeuroses (Fig. 77, and fig. 2, Plate XLIX.), extend the second and third phalanges. The fourth finger is flexed at the first phalanx chiefly by the fourth Dorsal Interosseous muscle.

Fig. 77.



THE FOURTH FINGER OF THE LEFT HAND, WITH ITS DORSAL INTEROSSEOUS OR ADDUCTOR.—*a*. Dorsal interosseous or adductor. *b*, *b*. Phalangeal tendon of the dorsal interosseous. *c*. Tendon of the common extensor of the fingers. *d*. Aponeurotic expansion uniting the phalangeal tendon of the interosseous to the tendon of the common extensor of the fingers.

The muscles are thus seen to assist the lumbrical muscles in some of their movements, and the digital flexors and extensors in others.

Duchenne[1] has paid special attention to these muscles, both in their physiological and clinical relations. According to this authority, individuals who have lost the use of the Interossei and the Lumbricales, can neither extend the second and third phalanges nor flex the first, while those who have lost the use of both the flexors and extensors (properly so named), can yet flex the first phalanges and extend the second and third.

These muscles do not entirely fill the spaces in which they are found, thus permitting a portion of each Dorsal Interosseous muscle to appear at their sides.

The first dorsal, according to Henle, receives a slip of origin from a tendinous arch which runs over the deep branch of the radial artery from the anterior surface of the trapezium to the dorsal surfaces of the bases of the first two metacarpal bones.

Neither the palmar nor the dorsal Interossei appear to be endowed with a high degree of sensibility. Portal refers to instances of religious fanatics and mountebanks piercing the interosseous spaces without appearing to suffer much from the self-inflicted wounds.

Nerve.—The Interossei, both Palmar and Dorsal, as well as the Flexors and Abductors of the thumb, receive their nerve supply from the ulnar nerve, and are paralyzed after its section.

Each Interosseous muscle is a remnant of the Metacarpo-phalangeal Flexor of quadrupeds. This muscle as it exists in the cat, consists of a single metacarpal belly and two heads, each being inserted into the border of the base of the first

[1] Physiologie des Mouvements.

phalanx through the medium of a sesamoid bone. In the human subject the muscle appears in the hand only in the Flexor Brevis Pollicis. But if the Interossei be examined with this ideal muscle before the mind, it will be seen (conceding the sesamoid bone to be lost, and the belly of the muscle to have undergone longitudinal cleavage) that the flexor is represented in the second finger by the first Dorsal Interosseous on the lateral border, and by the first Palmar Interosseous on the median. In the third finger, both the elements are represented in the second and third Dorsal Interossei. In the fourth the lateral element is seen in the second Palmar, and the median in the fourth Dorsal. In the fifth finger the Flexor Brevis Minimi Digiti represents the median portion of the common Flexor, the lateral being in this instance the third Palmar Interosseous.

(2) The Fasciæ.

The fascia of the upper extremity is freely continuous with the fascia of the trunk by means of that covering the Pectoralis Major, the Deltoid, and the Latissimus Dorsi muscles. It is weak as it lies upon these muscles; it is better developed upon the arm, and best developed in the region of the hand. It is strengthened by slips from the Biceps Cubiti and Palmaris, and by septal slips passing down to the scapula and the bones at and below the elbow-joint. It affords surfaces of origin to many of the muscles.

The lines of union between the exserted portion of the upper extremity (namely, from about the insertion of the Pectoralis Major) and the trunkal portion (namely, the portion at the sides of the trunk held by the clavicle and the scapula) are marked by two fasciæ that demand separate description.

These are—

The Axillary Fascia.
The Costo-Coracoid Fascia.

The Axillary Fascia is a thin sheet covering the axilla, and is continuous at the sides with the fascia covering the adjacent muscles. It incloses and protects the lymphatics, a deeper layer overlying the axillary vessels and nerves, and is in part continuous with the insertion of the Pectoralis Minor and with the origin of the Coraco-Brachialis muscle. It is in part also attached to the coracoid process, and is continuous with the coraco-clavicular fascia. Occasionally delicate arched muscular fibres cross the axillary fascia from the Latissimus Dorsi to the Pectoralis Major muscle.

The Costo-Coracoid fascia is included among the deep fasciæ of the upper extremity. It lies between the under surface of the clavicle and the coracoid process, passes inward and downward, and divides into two layers which are inserted upon the under surface of the clavicle between the coracoid and the rhomboid ligaments. Between the two layers of coraco-clavicular fascia is lodged the Subclavius muscle. The superior layer is thicker than the inferior, and passes without union with the latter to the coracoid process. At its point of origin the fascia sends a thin expansion to the brachial fascia at the axilla, where a deeper portion enters into the sheath for the axillary vessels. Lying above the coracoid attachment is the origin of the Pectoralis Minor muscle. The fascia serves to protect the parts escaping beneath the clavicle, and to support the already stout bands of union between the clavicle and the scapula. The finger cannot be passed far under the bone in consequence of the presence of this membrane. An offshoot from the upper surface of the membrane is continuous with the fascia over the Pectoralis Minor muscle.

Fascia of the Arm.—The fascia over the Biceps muscle is thicker than that over the Brachialis Anticus and the Supinator Longus. With the last-named muscle it is closely incorporated. It becomes stouter near the elbow, where it is continuous with the fascia of the forearm. The fascia over the Triceps muscle is in turn thicker than that over the Biceps,

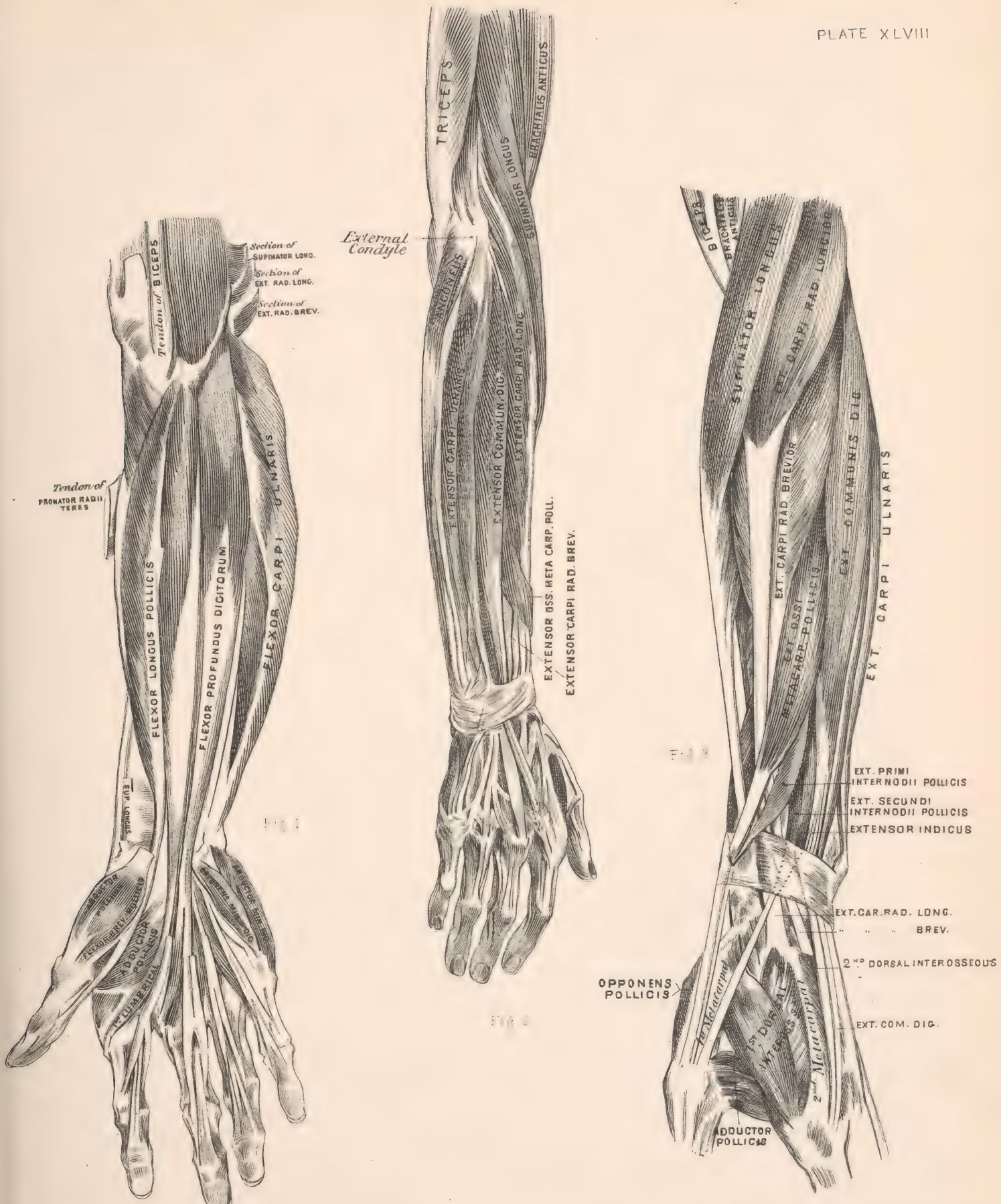
EXPLANATION OF PLATE XLVIII.

Fig. 1. The same, in part, as Fig. 2, Plate XLVII., but from the opposite side of the body. The flexor longus pollicis and the flexor carpi ulnaris are retained in position, and the insertion of the supinator longus is seen. The hand is drawn entire throughout, and its superficial muscles displayed.

Fig. 2. The superficial muscles of the forearm, seen from behind; the hand and the lower portion of the arm are displayed.

Fig. 3. The superficial muscles of the lateral (radial) border of the forearm, together with some of the muscles of the hand.

PLATE XLVIII



T. Sinclair & Son, Lith.

and partially underlies the scapular division of the Deltoid muscle. To the median side of the arm the anterior and posterior sheets are continuous over the sheath of the brachial artery and over the vein and the main nerve trunks At the lower third of the arm the fascia is pierced by the basilic vein, by the internal cutaneous nerve, and by the cutaneous branch of the musculo-spiral nerve.

The External Intermuscular Septum extends from the epicondyle upward as far as the insertion of the Deltoid. It answers in position to the external supra-condyloid ridge, and separates the Brachialis Anticus, the Supinator Longus, and the Extensor Carpi Radialis Longior from the Triceps. The musculo-spiral nerve and superior profunda artery pass through it.

The Internal Intermuscular Septum extends from the base of the epitrochlea upward along the line of the supra-trochlear ridge as far as the insertion of the Coraco-Brachialis muscle. In front fibres of the Brachialis Anticus arise from it, and behind fibres of the Triceps. This septum differs from the external in having a conspicuous fibrous band which is continuous with the tendinous fibres of origin of the Coraco-Brachialis muscle, which pass to the inner side of the septum as far as the free end of the epitrochlea This structure is called the *internal brachial ligament* by Struthers.[1] Behind the band near the elbow lies the ulnar nerve.

Fascia of the Forearm.—The fascia of the forearm is firmer below than above. It is strengthened near the elbow by oblique fibres, and passes to the sides from the fascia of the upper arm, and by the semilunar fascia from the tendon of insertion of the Biceps Flexor. It affords attachment to muscular fibres. Thus the Flexor Carpi Ulnaris in part, the Flexor Sublimis Digitorum, the Flexor Profundus Digitorum, the Extensor Carpi Radialis Brevior, and the Extensor Communis Digitorum, arise from this fascia. The fascia is free below the fibres of origin of these muscles. Posteriorly it may be said to be continuous with the fascia covering the Triceps and Anconeus muscles. Near the wrist it surrounds some of the tendons of the muscles, notably those of the Palmaris Longus in front, and of the radial extensor muscles. The radial artery and nerve are inclosed in a fascial membrane of loose texture; this is continued across the arm to the ulnar border. This membrane answers to the posterior layer of a sheath covering the Flexor Sublimis Digitorum.

The fascia of the forearm is much stouter than that of the arm. At the sides, and in front of the elbow it is stouter than behind. The fascia covers the forearm as a tight-fitting gauntlet, and is divided for convenience into three parts, viz.: (1), that over the Supinator Longus and the two Radial Carpal Extensors; (2), that originating over the epitrochlea and the muscles arising from it; and (3), that originating at and between the epicondyles and the olecranon.

(1) The fascia over the Supinator Longus and the two Radial Carpal Extensors is closely incorporated with the fibres of these muscles. Below it holds the tendon against the radius, and retains the tendons of the extensors of the thumb firmly in their oblique position. It ends laterally in the external intermuscular septum, and at the fascial slip overlying the Supinator Brevis.

(2) The fascia arising from the epitrochlea is continuous laterally with that over the Supinator Longus, and incloses the radial artery in the superficial portion of its course. It is held firmly to the Pronator Radii Teres and the Flexor Carpi Radialis muscles, while affording large surfaces of origin to them. To the ulnar side of the forearm it incloses the tendons of the Palmaris Longus and of the Flexor Carpi Ulnaris.

The fascia, after having been dissected from the radial to the ulnar border of the forearm along the line of these tendons, can be removed with ease from the Pronator Radii Teres and the Flexor Carpi Radialis muscles at their distal halves; but it is firmly united with them at their proximal halves. It cannot be raised from the tendons of the Palmaris Longus and of the Flexor Carpi Ulnaris; but the latter are raised with it, and the fascia inclosing them is found attached to the ulna at its radial posterior border, where it assists in the formation of an intermuscular septum. The fascia cannot be raised from the muscles between the epicondyle and the olecranon at the proximal third of the forearm.

(3) The fascia extending from the epicondyle to the olecranon, and thence down the dorsal aspect of the forearm, is in immediate connection with the Extensor Communis Digitorum and the Extensor Carpi Ulnaris. It cannot be raised at any point for any considerable distance without making an artificial dissection. A well-defined intermuscular septum dips down between the Extensor Communis Digitorum and the Extensor Carpi Ulnaris, and the entire division of fascia is firmly attached to the ulna for nearly its entire length.

The fascia of the forearm, as it passes to the hand, is called the *annular ligament.* The annular ligament

[1] Brit. and Foreign Med.-Chir. Rev., xiv. 1854, 225, note.

results, indeed, from the simple thickening of this fascia. It extends in the main from the anterior distal ends of the radius and the ulna, and protects, while affording a pulley-like band for, the muscles passing beneath it to the hands. It is strengthened by bands from the pisiform bone. In the undissected subject its position is indicated by a transverse fold in the skin.

Remarks.—Coulson[1] describes, in connection with the superficial fascia, a number of bursæ, as follows: a bursa in the axilla; one over the internal epicondyle, which has been known to assume the size of a walnut; one over the olecranon; one at the distal end of the radius; one at the distal end of the ulna; one at the carpus (this may often become enlarged, and contain about a drachm of fluid); a large bursa over the first joint of the thumb; other bursæ, often double, over the first and second joints of the fingers.

The annular ligament, in its practical relations, is perhaps the most important portion of the fascia of the forearm. When the sheaths of the flexors are distended by an excess of fluid, it divides the swelling into two parts, since it is too rigid to yield to pressure.[2] Symes[3] recommends its division in distension of the sheaths of the fingers. According to Sir Charles Bell,[4] the fascia in inflammatory states of the arm acts as a bandage, and constricts the parts beneath without itself becoming either inflamed or contracted. In marked examples the forearm may be flexed on the arm, and the fingers may be flexed. Free incisions of the fascia are recommended to relieve the tension.—Nelaton[5] describes a condition of deep-seated suppuration in the forearm in which the pus appears to originate about the tendon of the Flexor Longus Pollicis, the sheath of which participates in the disease, and thence passes to the front of the interosseous ligament and the Pronator Quadratus. He recommends that an incision be made laterally: viz., near the radial margin of the forearm, using the tendon of the Flexor Carpi Radialis as a guide, and thence boldly pushing down through the Flexor Profundus.

The Palmar Fascia.—Under the name of the Palmar Fascia is embraced the delicate aponeurosis lying beneath the skin of the palm. Its longitudinal fibres are in continuity with the tendon of the Palmaris Longus and receives accessions from the fascial layer of the annular ligament about the wrist. It gives shape to the body of the hand, assists in the formation of the web of the fingers, provides slips extending to the metacarpal bones, and aids in the formation of sheaths for the Lumbricales and Interossei muscles.[1]

The bands assisting to form the web of the fingers are known as the "fibres of Gerdy." These are the most conspicuous of the transverse fibres of the fascia. They are specially well developed at the distal border, where they so unite the first row of phalanges as to interfere with the complete separate flexion of any one finger.

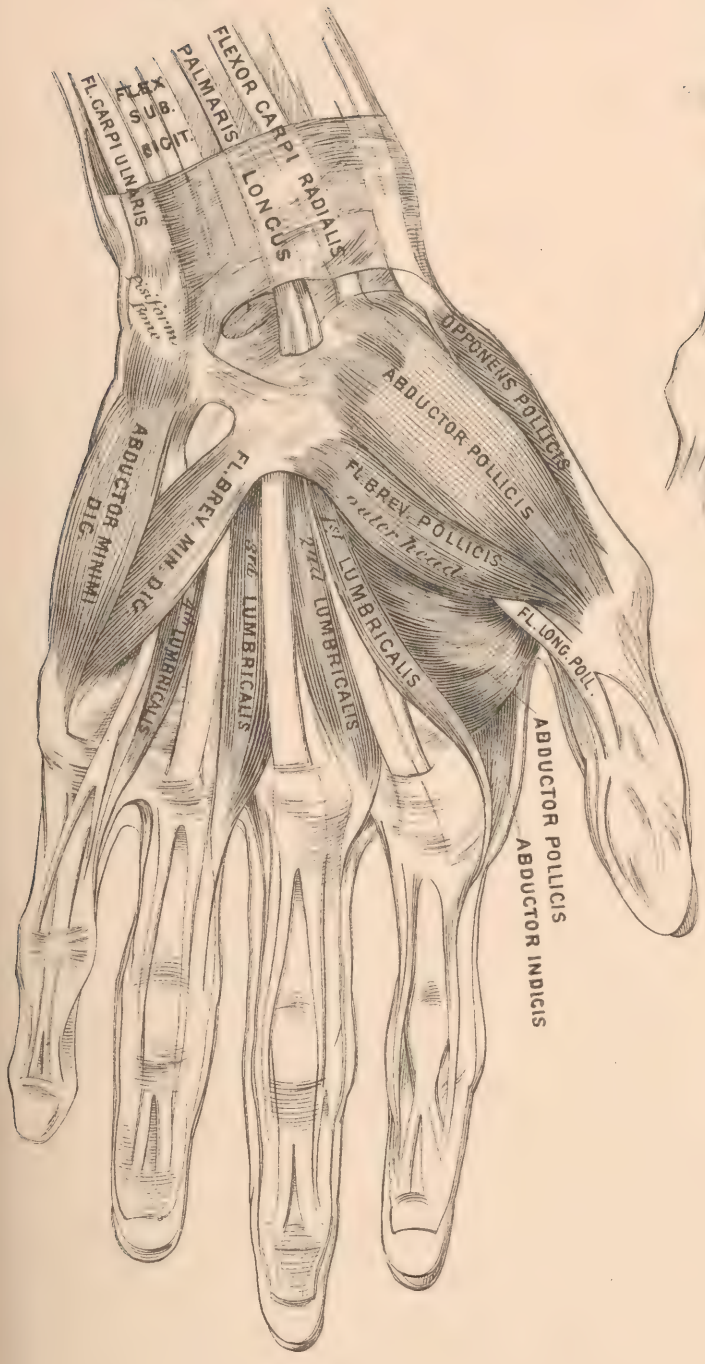
[1] Lond. Med. Journ., 1851.
[2] Coulson, Lond. Med. Journ., 1851.
[3] Edinburgh Monthly Journ., Oct. 1844.
[4] Surgery, i. 67.
[5] N. Y. Med. Journ., April, 1866 (from vol. iii. Journ. of Prac. Med. and Surg.).

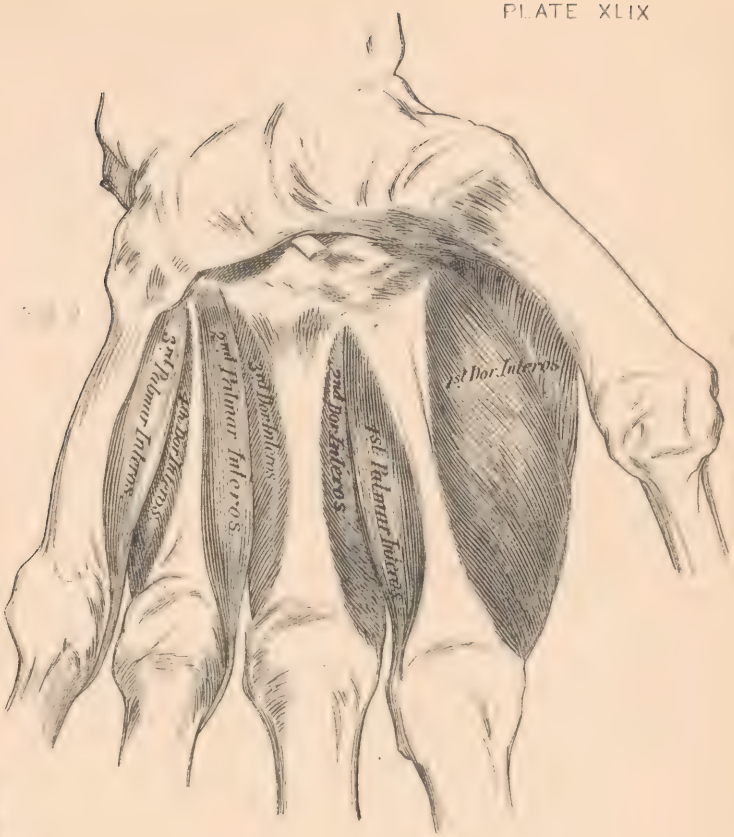
[1] In the course of an elaborate study of the palmar fascia in connection with "Dupuytren's Finger Contraction," my friend Dr. W. W. Keen has called attention to this feature. Arching over from one metacarpal bone to the other are three strong fibrous bands, posterior to which lie the Interosseous muscles.—From the under surface of the fascia, as it reaches the level of the knuckles, eight or nine more or less well-marked partitions arise and pass posteriorly to be attached as follows: four of them reach the metacarpals, blending with the arching fibrous bands just described; the others are attached directly to these bands at points between their bony attachments. These partitions or pillars form seven distinct canals. Through four of these pass the flexor tendons of each finger in pairs. Through the other three pass the three ulnar Lumbricales, and with them the interosseous artery and the digital nerves. The radial or first Lumbrical muscle is sometimes included in a separate canal, more often it is not. These canals secure the flexor tendons in the palm.

EXPLANATION OF PLATE XLIX.

Fig. 1. The muscles of the palmar surface of the hand.
Fig. 2. The interossei muscles, seen from the palmar surface.
Fig. 3. The interossei muscles, seen from the dorsal surface.

PLATE XLIX







T. Sinclair & Son Lith.

V. THE MUSCLES OF THE INFERIOR EXTREMITY.

The Muscles of the Hip.

The muscles of the hip include—

The Gluteus Maximus.
The Gluteus Medius.
The Gluteus Minimus.
The Pyriformis.
The Obturator Internus.
The Obturator Externus.
The Quadratus Femoris.

THE GLUTEUS MAXIMUS.

The Gluteus Maximus is the coarsest muscle in the body. It is a broad fasciculated mass giving prominence to the buttock.

It arises from the posterior fifth of the outer lip of the crest of the ilium, from the posterior surface of the lumbo-sacral aponeurosis, from the lateral border of the sacrum and coccyx, and from the sacro-iliac ligament along its entire extent. The fibres pass downward and outward, forming a quadrilateral mass thicker at the centre than at the borders. The muscle is inserted into the femur at a part answering to the expanded outer lip of the produced linea aspera, as well as into the fascia lata, from a point near the base of the great trochanter to one near the middle of the thigh.

The muscle is fleshy throughout the greater part of its course. The thick aponeurosis arising from the anterior portion of the crest of the ilium is continuous with the Gluteus Maximus at its upper and anterior border and may be said to constitute part of it as well as part of the Gluteus Medius, with which muscle it is described.

The fibres arise by two concentric lines, the superficial and the deep; the *superficial* form an arched line extending from the lumbo-sacral fascia to the sacral cornu; the *deep*, from the outer border of the sacrum and the great sacro-sciatic ligament. — The insertion of the muscle may be minutely described as follows: The upper fibres are parallel with a thick fibrous lamina which passes over the great trochanter. They are inserted on a duplication of the fascia lata, as well as on the femur. The inferior fibres have a large but short tendon, which is continuous above with the preceding lamina, and with the aponeurosis of the external portion of the Quadriceps Extensor. They are attached to the outer lip of the linea aspera and to the parts above this line.—The majority of the fibres are inserted into the fascia lata; the lower part only is tendinous, and is inserted into the femur at the height of the lesser trochanter at the line of the upper outer limb of the linea aspera.

Between the tendon and the lower part of the great trochanter and extending thence a short distance along the Vastus Externus, a large bursa is seen. A second bursa, lying between the muscle at the great trochanter and the skin, may suppurate and simulate hip-joint disease.[1]

Relations.—Above to the inner and outer side lie the skin and a thin translucent fascia. Below lie the Gluteus Medius, Pyriformis, and Quadratus Femoris muscles, the tendon of the Obturator Internus, the Gemelli, the superficial branch of the gluteal artery, the greater and lesser sciatic nerves, the great trochanter, the tuberosity of the ischium, and the pelvic origin of the hamstring muscles. Also beneath the muscle, and lying in the space between the great trochanter and the tuberosity of the ischium, are the inferior gluteal vessels.—The muscle forms in part the outer border of the ischio-rectal fossa.

The lower border is the inferior boundary of the nates. It is tense when the muscle is contracted. Hence the value of this line in detecting painful conditions of the hip-joint, especially coxalgia in its first stage. The patient will not place any weight upon the affected thigh, the fascia lata and Gluteus Maximus are relaxed, and the "fold of the buttock" sags downward.

The fibres of the Gluteus Maximus are divided in operations upon the gluteal artery. Lizar's line is drawn from the posterior superior spinous process of the ilium downward between the tuberosity of the ischium and the great trochanter.

Use.—The Gluteus Maximus forcibly extends the thigh upon the pelvis. When the anterior fibres of the muscle act alone the femur is rotated inward. It is probable that when the posterior fibres act alone the bone is rotated outward.

According to Duchenne, it is not so efficient in preserving the erect position or in the act of walking as has been generally supposed. The muscle aids in certain motions of the limbs, such as are made in ascending stairs, in leaping, in dancing, and in rising from a sitting posture. When the muscle is atrophied, the extending force of the limb is impaired, notably when weights are borne upon the shoulders.

Nerve.—The muscle is supplied by the superior and inferior gluteal nerves.

Variations.—A tendency exists for Longitudinal cleavage to take place between the coccygeal and sacral fascicles. The former are then homologous with the Agitator Caudæ of many quadrupeds. Slips may arise from the lumbar aponeurosis, the sacro-sciatic ligament, and the ischial tuberosity.

[1] T. G. Teale, Lancet, Oct. 1870, p. 506.

THE GLUTEUS MEDIUS.

The Gluteus Medius muscle arises fleshy from the anterior three-fourths of the external lip of the crest of the ilium, from the space upon the dorsum of the ilium between the superior and middle semicircular lines, from a tendinous arch—stretching from the outer border of the sacrum to the upper border of the great sciatic notch—and from the fascia lata. The anterior border is more or less united with that of the Gluteus Minimus, as the two layers of the Masseter are united at the anterior border of that muscle. The fibres of the Gluteus Medius converge from the point of origin; the posterior group, being the more oblique, passes downward and forward to be inserted tendinously into the outer aspect of the great trochanter throughout its extent.

A small bursa lies between the tendon and the Pyriformis muscle, and another between the muscle and the great trochanter.

W. Macewen[1] notes a case in which this bursa became enormously distended and was opened by a surgeon. A second time it spontaneously discharged, and was finally permanently healed by free incision, the use of stimulating injections, and rest.

Use.—The posterior fibres aid in rotating the thigh outward, and the anterior fibres in rotating it inward (see account at end of Gluteus Minimus).

Nerve.—The muscle is supplied by both the superior and the inferior branches of the superior gluteal nerve.

The muscle secures an attachment from the anterior superior spinous process of the ilium, and from the depression beneath it. A fibrous line, more or less pronounced (sometimes being a tendon which divides the muscle), lies in the middle of the mass, and separates the posterior from the anterior fibres. The muscle is radiated, with a concealed tendon.

Relations.—In front lie the Gluteus Maximus and the fascia lata in part; behind lie the Gluteus Minimus, the dorsum of the ilium, and the superior gluteal vessels and nerves. Anteriorly it is continuous with the Gluteus Minimus and with the Tensor Vaginæ Femoris. When the femur is rotated outward the lower fibres of the tendon overlie the Vastus Externus.

Variations.—The fusion with the Gluteus Minimus at its anterior border is subject to variation. Posteriorly the muscle may fuse with the Pyriformis.

[1] Glasgow Medical Journal, 1876, 477.

THE GLUTEUS MINIMUS.

The Gluteus Minimus muscle arises from the dorsum of the ilium between the superior and the inferior curved line. It also arises from a small portion of the crest anteriorly, and from the anterior border of the great sciatic notch. Its fibres are in part continuous with the corresponding border of the Gluteus Medius. The fascicles converge to form a narrow tendon, which is inserted on the anterior border of the great trochanter. Beneath it lies a small bursa.[1] A shining aponeurosis is extended on the outer surface of the muscle.

Relations.—Above lie the Gluteus Medius and the deep gluteal artery. Below are the innominate bone, the posterior portion of the capsule of the hip-joint, the acetabular head of the Rectus Femoris in part, and the origin of the Vastus Externus. In front lies the Tensor Vaginæ Femoris.

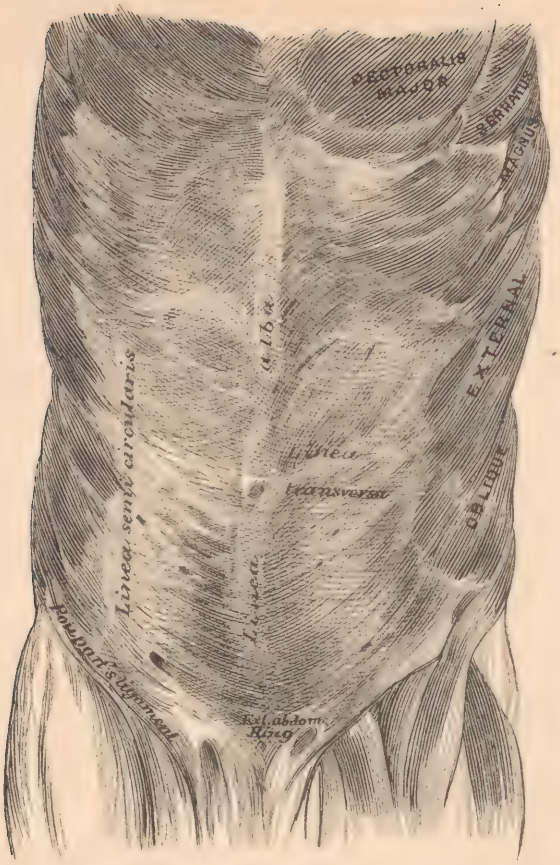
Use.—Action upon insertion: The muscle is composed functionally of two fasciculi having different lines of action. The anterior part carries the limb obliquely forward and inward. The posterior portion initiates a movement of rotation from within outward. —Action upon origin: Together with the Gluteus Minimus the Gluteus Medius fixes the pelvis upon the thigh both during rest in the erect position and in the second stage of the act of walking. This fact is proved clinically, since in paralysis of the Gluteus Medius and the Gluteus Minimus the pelvis is inclined to the opposite side at the moment when the body rests upon the affected limb, notwithstanding that the Gluteus Maximus is in a healthy condition.

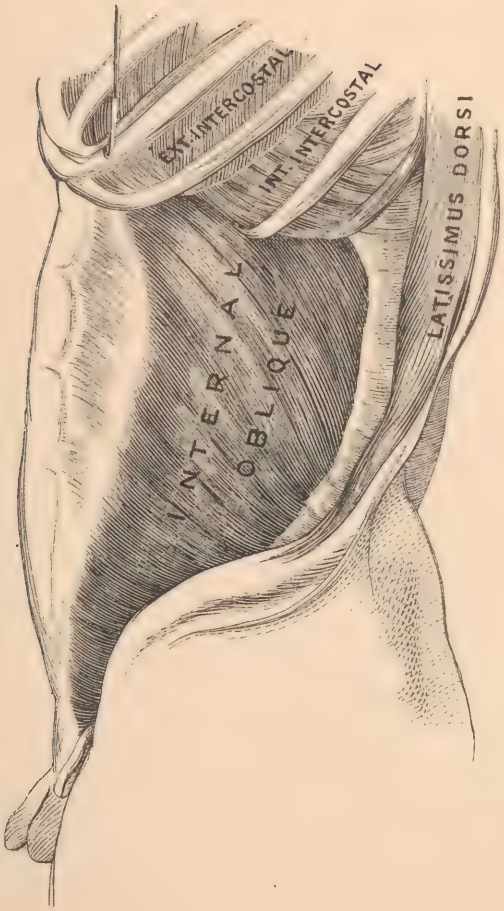
Nerve.—Supplied by the superior and inferior branches of the superior gluteal nerve.

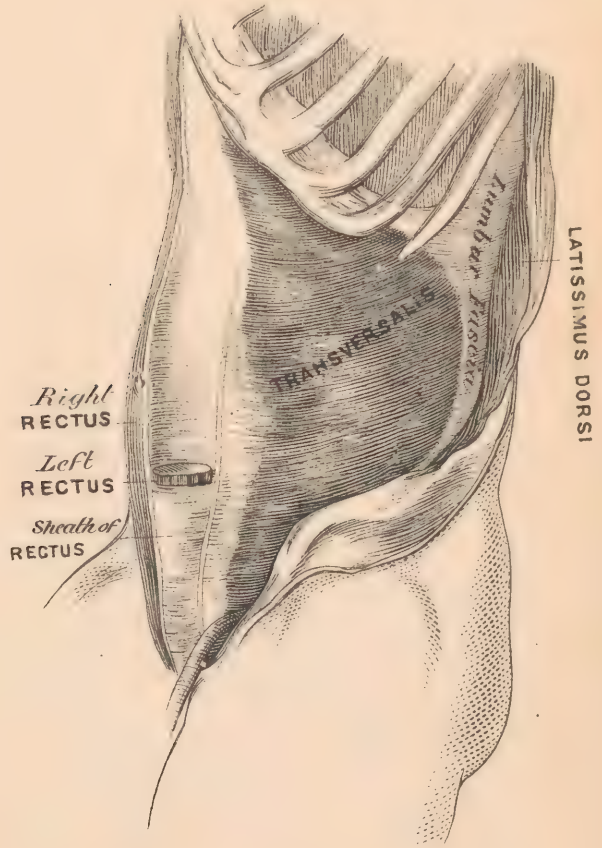
[1] H. Meyer (Zeit. für Anatomie und Entwickelungsgeschichte, 1876, 29) describes the Gluteus Minimus muscle as the type of the gluteals to which the Gluteus Medius and Gluteus Maximus stand in the relation of planal repetitions (Verdoppelungs muskeln).

EXPLANATION OF PLATE L.

Fig. 1. The superficial muscles of the abdomen.
Fig. 2. The internal oblique muscle of the abdomen.
Fig. 3. The transversalis muscle of the abdomen.


PECTORALIS MAJOR
DELTOIDES
BICEPS
EXTERNAL OBLIQUE
Linea alba
Linea semicircularis
Linea transversæ
Poupart's ligament
Ext. abdom. Ring


EXT. INTERCOSTAL
INT. INTERCOSTAL
INTERNAL OBLIQUE
LATISSIMUS DORSI


Lumbar Fascia
TRANSVERSALIS
Right RECTUS
Left RECTUS
Sheath of RECTUS
LATISSIMUS DORSI

Variations.—The anterior portion of the muscle may be partially or entirely distinct from the rest of the muscle forming the slip—constant in some of the man-like apes, and occasionally seen in the coati—known as the Scansorius. This slip, or head as some writers denominate it, may be intimately associated with the Sartorius and the Tensor Vaginæ Femoris.—The muscle may be in close union with the capsule of the hip-joint. Its insertion into the trochanter may be strengthened by a slip from the ilio-femoral fascicle of the capsule.—A slip may pass from the muscle to the fascia lata.

The following table may serve a useful purpose in correlating the functionally separated portions of the gluteal muscles with other anatomical facts.

Anterior portions of Gluteus Medius, Gluteus Minimus (scansorial fibres), Tensor Vaginæ Femoris,	Rotate the thigh inward, in which act they are assisted by the anterior fibres of the Gluteus Maximus. Tend to fuse with one another. Arise from the innominate bone from the first concavity of the dorsum (see p. 186) by nearly vertical fibres, and are in close association with the fascia lata.
Posterior portions of Gluteus Medius, Gluteus Minimus,	Rotate the thigh outward, in which act they are assisted by the posterior fibres of the Gluteus Maximus, Pyriformis, Obturator Internus, Obturator Externus, Quadratus Femoris, and Adductor Muscles. Tend to fuse with the Pyriformis, and with the posterior fibres of the Gluteus Maximus. Arise from the innominate bone by oblique fibres beyond (*i. e.*, posterior to) the first concavity, and are nearly free from the fascia lata.

THE PYRIFORMIS.

The Pyriformis muscle arises from the antero-lateral surface of the sacrum at the intervals between the grooves of the second and the fourth sacral foramina, from the ilium at the great sciatic notch, and near the sacro-iliac junction, and from the great sacro-sciatic ligament. The muscle passes nearly horizontally outward through the great sacro-sciatic foramen, and is inserted into the femur at the upper border of the great trochanter. It is here in close connection with the tendon of the Obturator Internus.

Use.—Besides rotating the femur outward, it at the same time induces an oblique movement backward and a little outward, after the manner of the most posterior of the fibres of the Gluteus Medius and the Gluteus Minimus muscles.

Nerve.—It is supplied by a branch of the sacral plexus.

Relations.—In front lie the rectum, the sacral plexus of nerves, and the internal iliac vessels as the muscle lies within the pelvis, and the capsule of the hip-joint without. Behind lie the sacrum and the innominate bone. Above it lies the Gluteus Medius, and below it the Obturator Internus. The Gluteal vessels and nerves lie at its upper border.

The central tendon is composed of thin pearly fibres beneath. It is more or less continuous with the capsule of the hip-joint. The muscle may be considered to be an imperfectly differentiated slip of the Gluteus Medius.

Variations.—The muscle is sometimes double, allowing the great sciatic nerve to escape between the two bellies. It may fuse with the Gluteus Medius, with the Coccygeus above, and with the Obturator Internus below. It may be inserted into the capsule of the hip-joint.

F. S. Eve[1] found this muscle and the Gemelli ruptured in dislocation of the head of the femur backward.

[1] Med. Chir. Trans., lxii., 51.

THE OBTURATOR INTERNUS.

This muscle arises from the narrow strip of bone to the inner side of the obturator foramen, from the posterior surface of the obturator ligament, and from the bone as far back as the sciatic notch. It also arises from the tendinous arch which converts the sub-pubic (obturator) groove into a canal, and from the obturator fascia. It passes through the lesser sacro-ischiatic foramen, its tendon winding around the trochlear surface on the ischium, and is inserted into the femur at the bottom of the digital fossa. As it escapes from the pelvis the muscle receives a pair of accessory slips known as the Gemelli muscles.

The Superior Gemellus arises from the spine of the ischium; the Inferior Gemellus from the tuberosity, and in part from the great sacro-sciatic ligament. The two slips converge and form a groove-like inclosure for the tendon of the Obturator Internus, a short distance from its termination.

A bursa exists beneath the tendon at its point of reflection over the ischium. The tendon here is often marked by several minute longitudinal streaks. A second small bursa lies between the tendon and the fibrous capsule of the joint.

Variations.—Accessory slips of origin from within the pelvis below the ilio-pectineal line, and the parts about the margin of the inferior pelvic strait. Infrequently a slip may arise from the third sacral vertebra.—The Superior Gemellus may be absent, or be fused with the Obturator Internus. It may be distinct and inserted in the capsule of the hip-joint, or be fused either with the Pyriformis or the Gluteus Minimus.—The Inferior Gemellus may be absent, fused with, or compensatory with the Quadratus Femoris.

Use.—To rotate the femur outward, in which action it is aided by the Quadratus Femoris and the Obturator Externus. Under traction from the mus-

cles named the femur tends constantly to moderate rotation outward. Inversion is usually the result of impaired power in one or more muscles of the group.

The action of the Obturator Internus is antagonized by the anterior fibres of the Gluteus Medius and Gluteus Minimus muscles.

Nerve.—The Obturator Internus is supplied by a separate branch of the sacral plexus.

Relations.—Above the muscle lie the Gluteus Maximus, the great sciatic nerve, and the vessels escaping from the lesser sacro sciatic foramen. Beneath are a portion of the ischial tuberosity, the upper border of the Quadratus Femoris, and a large bursa. The muscle is tendinous in the interior. The tendon is broad, but more or less plicated.

Remarks.—H. J. Bigelow[1] finds that dislocation of the head of the femur upward and backward, "below the internal obturator tendon and the subjacent capsule," is "probably common, as the neck of the femur is here first arrested in its ascent from the frequent downward displacement which occurs while the limb is flexed, as it is in the great majority of such accidents." He proposes to call such displacements *luxations below the tendon* to distinguish them from *luxations above the tendon.* F. S. Eve[2] found the muscle ruptured in dislocation of the head of the femur upward and backward. He also found the Gemelli and Pyriformis muscles ruptured in dislocation of the head of the femur backward.[3]

THE OBTURATOR EXTERNUS.

The Obturator Externus muscle arises from the upper and the inner border of the obturator foramen and the corresponding portion of the obturator membrane, and from the transverse fibres which extend from the obturator membrane to the capsule of the hip-joint. The fibres converge to form a stout belly, which turns round the neck of the femur to be inserted by a stout rounded tendon into the femur at the posterior edge of the digital fossa, below the tendon of the Obturator Internus.

Use.—To roll the femur outward, and to support the head of the femur in the erect position.

Nerve.—The muscle is supplied by the obturator nerve.

In a case of long standing hip-disease, recorded by Mr. Hulke,[1] pus found its way into the pelvis, whence it was guided by the tendon of this muscle to the obturator membrane, piercing which it was conducted to the exterior of the pelvis. Dense fascia excluded this collection from the pelvic cavity.

Variations.—Slips may pass from this muscle to the Adductor Brevis. Unimportant fascicles arising from the walls of the true pelvis may contribute to the body of the muscle.

The fact that the muscle may contribute to the composition of an Adductor muscle, and that it is supplied by the same nerve as the Adductor group, places the Obturator Externus in close relationship to the Adductors.

THE QUADRATUS FEMORIS.

The Quadratus Femoris arises from the lateral border of the tuberosity of the ischium, and passes horizontally outward to be inserted on the femur at a vertical line (*linea quadrati*) extending downward from the centre of the intertrochanteric line toward the linea aspera.

Use.—To adduct the femur. From its tendency to fusion with the Gemellus Inferior it is probable that this muscle may assist in rotating the femur inward, and thus aid the muscles inserted into the digital fossa, while feebly antagonizing the muscular fibres supplied by the inferior gluteal nerve.

The fibres are short and interspersed with fibrous tissue or fat.

Nerve.—The muscle is supplied by a long and delicate branch from the sacral plexus.

[1] The Hip, p. 37. [2] Med.-Chir. Trans., lxii. 51.
[3] Ibid.

[1] Trans. Path. Soc. Lond., 1863, xiv. 213.

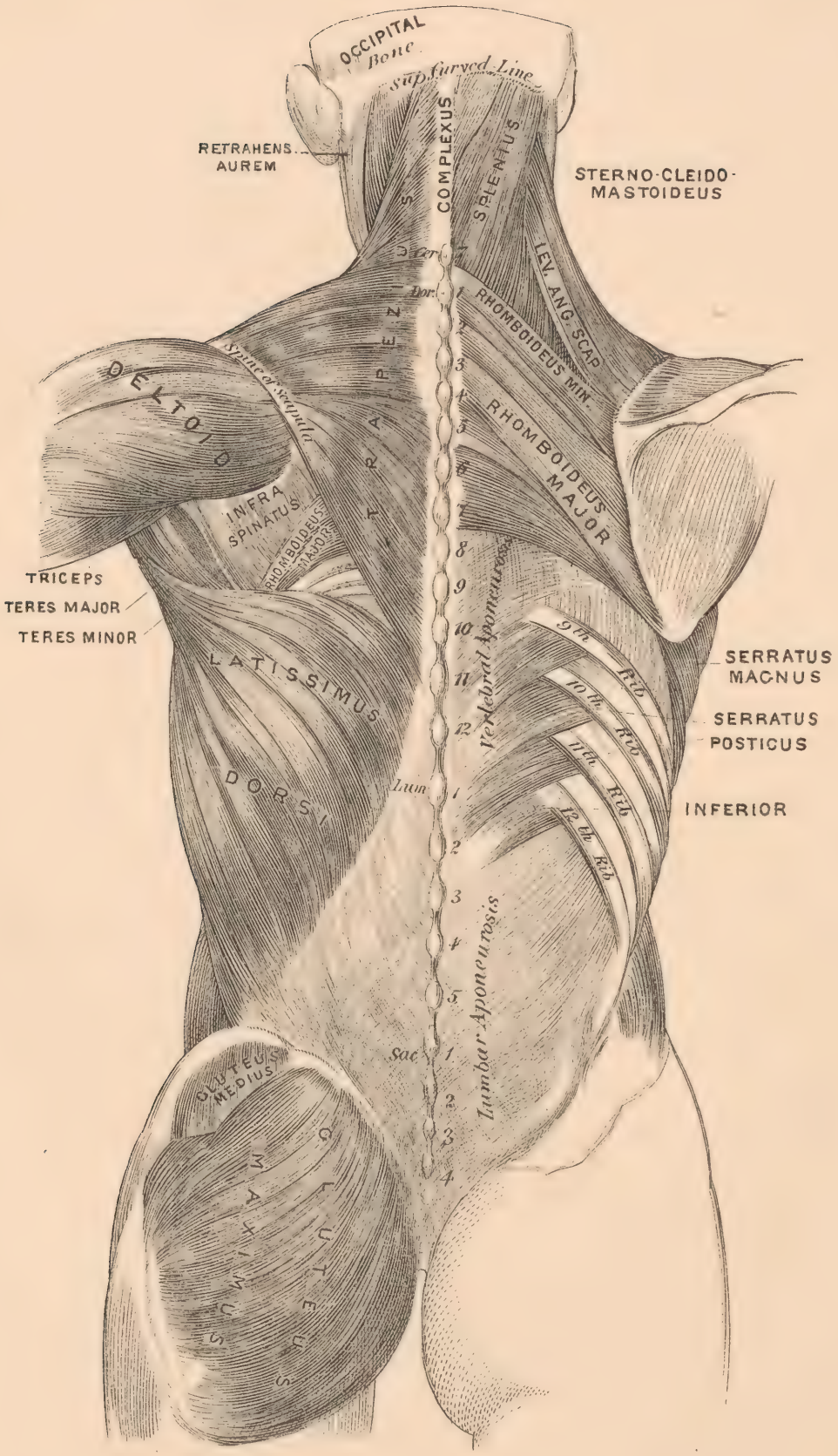
EXPLANATION OF PLATE LI.

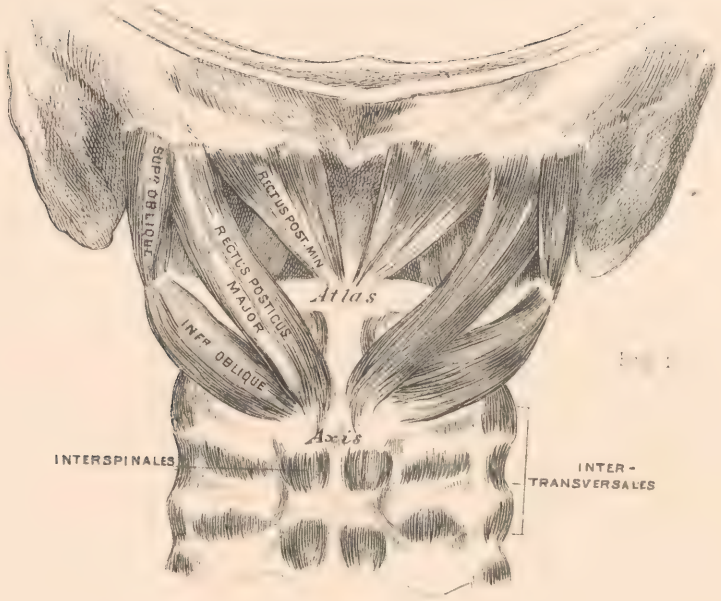
Fig. 1. The muscles of the back including the extrinsic muscles of the superior extremity.

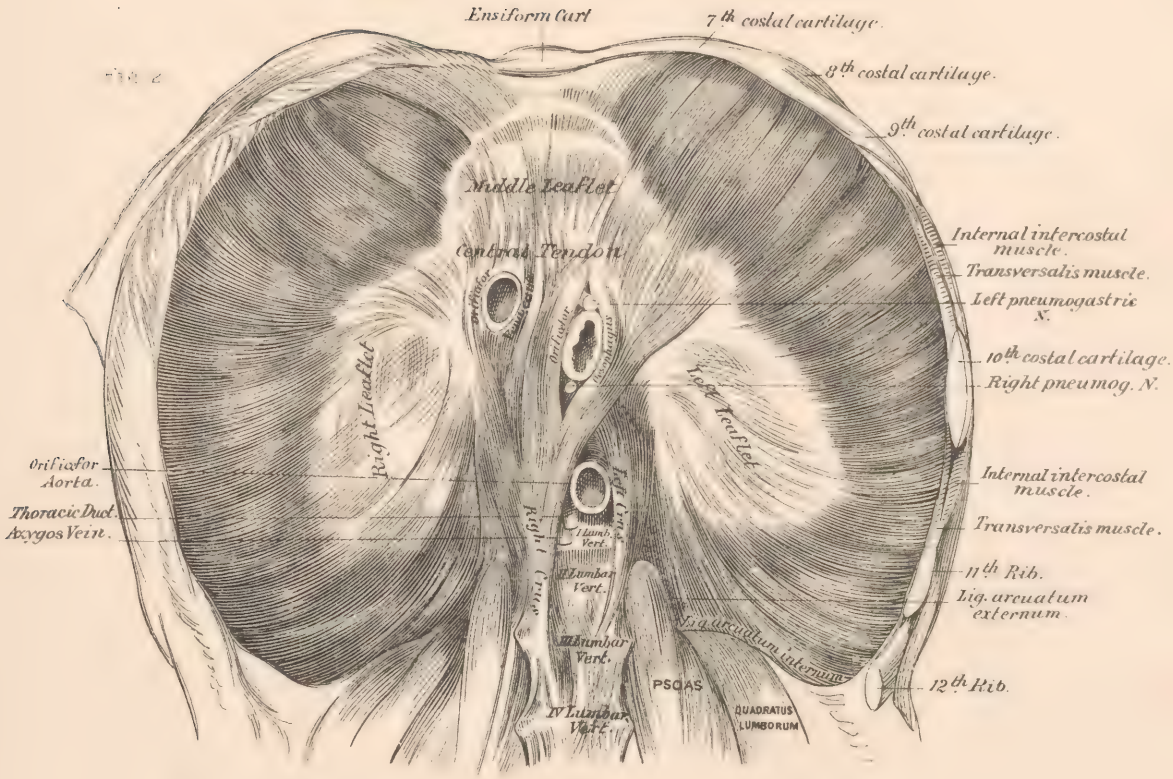
EXPLANATION OF PLATE LII.

Fig 1. The deep muscles of the nape of the neck.

Fig. 2. The diaphragm, seen from beneath.


OCCIPITAL Bone
Sup. curved Line
RETRAHENS AUREM
COMPLEXUS
SPLENIUS
STERNO-CLEIDO-MASTOIDEUS
TRAPEZIUS
Cerv.
Dors.
LEV. ANG. SCAP.
RHOMBOIDEUS MIN.
RHOMBOIDEUS MAJOR
Spine of scapula
DELTOID
INFRA SPINATUS
RHOMBOIDEUS MAJOR
TRICEPS
TERES MAJOR
TERES MINOR
LATISSIMUS DORSI
Vertebral Aponeurosis
9th Rib
10th Rib
11th Rib
12th Rib
SERRATUS MAGNUS
SERRATUS POSTICUS INFERIOR
Lum.
Sac.
Lumbar Aponeurosis
GLUTEUS MEDIUS
GLUTEUS MAXIMUS





T. Sinclair & Son, Lith.

Variations.—It may be absent, when the Gemellus Inferior may take its place.—It may fuse with the Adductor Magnus, the Obturator Externus, and the Semimembranosus. Its insertion is apt to be divided into a number of separate fascicles.—It may send a fascicle to the great bursa beneath the Gluteus Maximus.—A bursa may lie beneath the muscle at the trochanter minor.

Relations.—The Quadratus Femoris is a member of the adductor group of muscles. It is separated from the Adductor Magnus by the internal circumflex vessels, and from the Semimembranosus behind by a quantity of adipose tissue. Above, it is crossed by the origin of the posterior femoral group of muscles, by the great sciatic nerve, and in part by the Gluteus Maximus muscle; behind by the Obturator Internus.

The Posterior Femoral or Hamstring Muscles.

The muscles of this group include—

The Biceps Flexor Cruris.
The Semitendinosus.
The Semimembranosus.

THE BICEPS FLEXOR CRURIS.

The Biceps muscle (external hamstring), as is implied by the name, possesses two heads—an ischiatic and a femoral. The ischiatic head arises tendinously from the tuberosity of the ischium in conjunction with the Semitendinosus; and for a short distance below the place of origin the two muscles are conjoined. The femoral or shorter head arises by fleshy fibres from the lower two-thirds of the linea aspera and the posterior surface of the sheath of the Vastus Externus (external intermuscular septum). This head forms a ribbon-shaped bundle, and joins the long head at its anterior surface to form the body of the muscle a short distance above the formation of the tendon of insertion. The muscle is inserted into the head of the fibula, and usually sends fibrous expansions to the external femoral condyle, to the fascia of the leg, and to the head of the tibia.

Near the insertion the muscle is aponeurotic on the superficial, and fleshy on the deep, surface. Near the origin it is fleshy on the superficial, and aponeurotic on the deep, surface. With care a dissection can be made showing the continuity of the origin of the Biceps with the great sacro-sciatic ligament.

Use.—To flex the leg on the thigh, and, to a slight degree, to extend the thigh on the pelvis. It usually acts with the Semitendinosus, which passes to the median side of the proximal end of the tibia, the Biceps passing to the corresponding end of the fibula. The two muscles pull the leg backward somewhat after the manner in which the reins held in the hand of the driver can pull back the head of a horse. When the muscle acts alone, it produces external rotation of the leg.—The tendon of insertion supports the capsule of the knee-joint laterally. To a slight degree it makes tense the fascia of the leg, and prepares the Peroneal muscles for action.

Undue or unantagonized action of the Biceps is seen in some of the forms of "knock-knee." It induces outward rotation of the leg, and accompanies some varieties of paralysis of the femoral inward rotators. This action of the Biceps connects the muscle functionally with the Gluteus Maximus (see fascia of lower extremity).

Nerve.—The muscle is supplied by branches from the great sciatic.

Relations.—In front lies the sciatic nerve, which follows this muscle more closely than it does the other hamstrings and the Adductor Magnus. The Gluteus Maximus covers in the origin. It aids in defining the popliteal space externally. The tendon of insertion is a guide to the external popliteal nerve which lies to the median side.—The muscle is exceptionally vascular.

The origin of the Semitendinosus lies behind that of the Biceps.—The superficial lamina of the Semitendinosus alone fuses with the Biceps.—A slip of the tendon lies behind the long external lateral ligament.—The tendon of insertion is attached to the fibula at the middle of the styloid process.—A bursa lies between the tendon and the capsule of the knee-joint. Enlarged conditions of this bursa have been detected in the living subject.[1]

Variations.—The femoral head of the Biceps may be absent. A second long head may arise from the tuberosity of the ischium. A third femoral head may arise from near the proximal end of the linea aspera. It may receive a fascicle from the Gluteus Maximus. It may arise in part from the great sacro-sciatic ligament and the sacral vertebræ. It may join the Gastrocnemius near the tendo Achillis, or a pelvic slip may reach the fascia of the leg. A slip may pass to the knee-joint and to the long external lateral ligament. The tendon of insertion, in part, is almost always continuous with the Peroneus Longus.

THE SEMITENDINOSUS.

This muscle arises from the tuberosity of the ischium, and from the tendon of the Biceps Flexor for about three inches. It forms a fusiform belly, which passes downward and inward to form a slender rounded tendon at about the middle of the thigh; and is inserted into the outer condyle of the femur, the

[1] W. Macewen, Glasgow Med. Journ. 1876, 469.

tubercle of the tibia, and by an aponeurotic slip into the fascia of the leg.

The muscle exhibits a tendinous inscription at about its middle.—A bursa is seen between the tendons of the Semimembranosus and the Semitendinosus.—The muscle is bilaminate for a short distance from its origin, the space between the laminæ receiving bloodvessels. The superficial lamina fuses with the Biceps; the deep lamina furnishes a small surface of origin for some of the fibres of the Semimembranosus.—The tendons of the Semitendinosus and the Gracilis pass through a loop at the upper and inner part of the deep fascia of the calf, and are thence inserted beneath the aponeurosis of the Sartorius. It may be said that the deep fascia of the leg is made tense by a pulley-like action on the part of the two muscles in question, as well as by the Sartorius.

Use.—To flex the leg on the thigh, and to rotate it inward.—In paralysis of this muscle (commonly associated with paralysis of the Biceps) the trunk has a tendency (the body being erect) to fall forward. The muscle, assisted by the Gracilis and Sartorius, makes the fascia of the leg tense.

Nerve.—This is derived from the great sciatic.

Relations.—In front are the Adductor Magnus, a few small bloodvessels intervening, and the tendon of the Semimembranosus in part. To the inner side, in front, lies the Semimembranosus. To the outer side lies the Biceps Femoris. The muscle assists in limiting the popliteal space medianly. It is singularly free from variation.

THE SEMIMEMBRANOSUS.

The Semimembranosus muscle arises, by a stout tendon, from the tuberosity of the ischium in front of the conjoined tendon of the Biceps and the Semitendinosus. The long tendon passes thence downward and inward to end abruptly in a large fleshy mass at the lower third or half of the thigh. This mass, the belly of the muscle, presents a rounded outer border, and is for the most part inserted into the inner tuberosity of the tibia. A careful examination of the tendon of insertion shows that it is composed of three portions, as follows: First, a large slip of fibres, passing inward and upward to the outer condyle of the femur, constitutes the posterior oblique ligament of the knee-joint; it aids in strengthening the ligament of Winslow. Second, a bundle of nearly vertical fibres answering to the main mass of the muscle is inserted into the internal tuberosity. Third, a set which is inserted into the inferior margin of the articular surface of the tibia.

This muscle and the Semitendinosus form the internal hamstrings.

A bursa exists beneath the origin of the Semimembranosus; and a second between the tendon of the muscle and the tibia.

W. Macewen[1] describes a bursa common to the Semimembranosus and the internal head of the Gastrocnemius.

Use.—The Semimembranosus flexes the leg on the thigh, and aids in extending the thigh on the pelvis. It aids in rotating the leg, and, in connection with the Biceps, the thigh also.

Nerve.—This is derived from the great sciatic.

Fergusson[2] describes an instance of a popliteal aneurism bursting, the blood entering the bursa lying beneath the Semimembranosus, and thence entering the knee-joint.—Bryant[3] mentions the rupture of this muscle near its origin in a man of sixty-five years. The rupture was caused by an attempt to lift a heavy weight while the body was bent forward.

Variations.—The muscle may be absent. It resembles the Biceps in a disposition to increased proximal origin, notably from the great sacro-sciatic ligament.—The three hamstrings may fuse at their origin, leaving a bursa within a cylinder-like fibrous tendon.

Relations.—The tendon of origin lies in front of the common origin of the Biceps and the Semitendinosus, and behind the Quadratus Femoris in part, and the Adductor Magnus. At the lower third of the thigh, it lies behind the Gracilis. With the Semitendinosus it aids in defining the inner border of the popliteal space.

A broad fascia extends from the median border of the tendon of the Semimembranosus, as it crosses the knee-joint; it lies beneath the deep fascia, and is lost over the Gastrocnemius muscle.

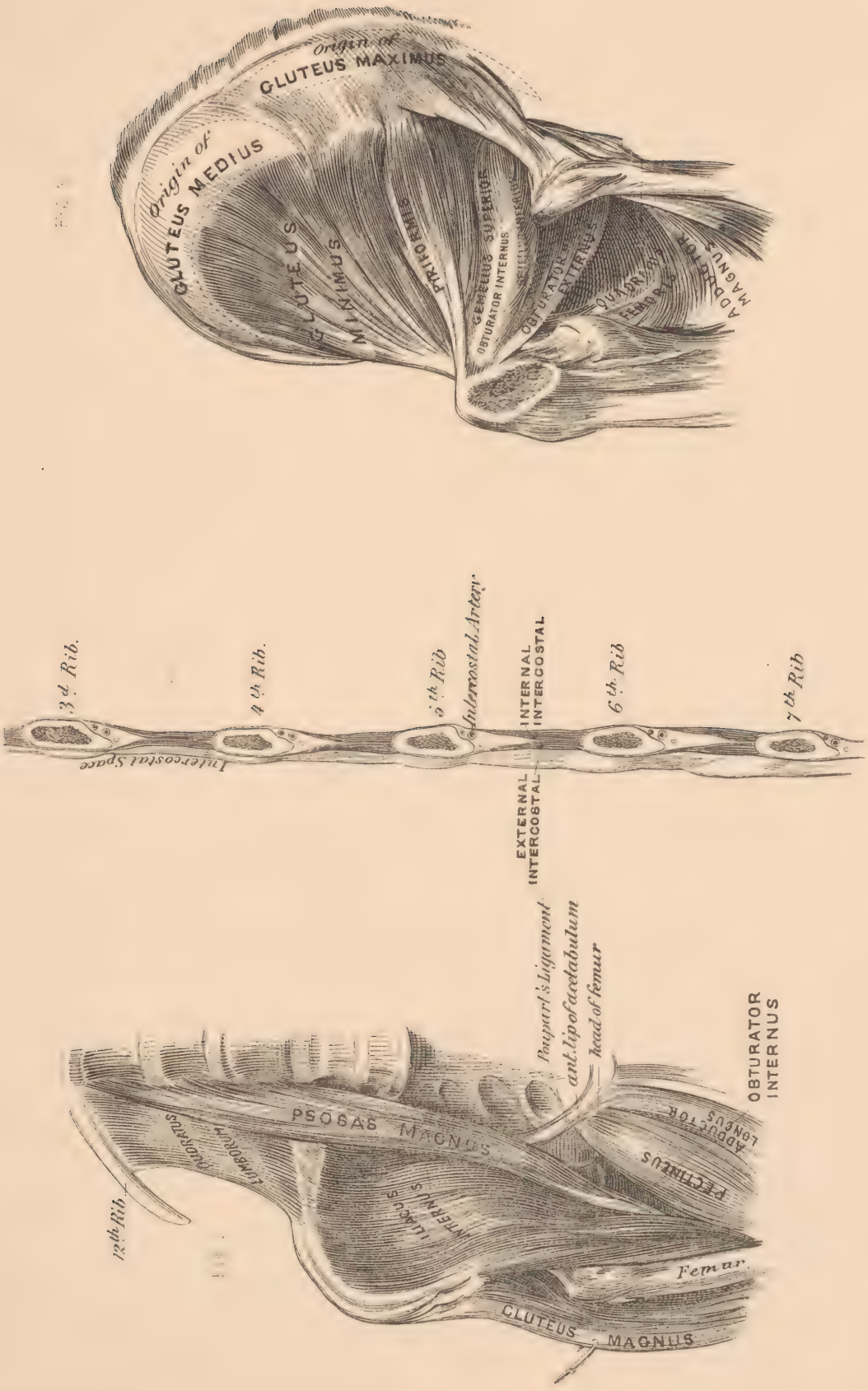
[1] Glasgow Med. Journ. 1876, 469.
[2] Trans. Path. Soc. Lond., ix. 122.
[3] Surgery, 899.

EXPLANATION OF PLATE LIII.

Fig. 1. The muscles of the groin and anterior aspect of the loin.

Fig. 2. Frontal section of a portion of the wall of the thorax, showing the position of the intercostal muscles.

Fig. 3. The deep muscles of the buttock.



T. Sinclair & Son Lith.

The Anterior Muscles of the Thigh.

The anterior muscles of the thigh are—
The Psoas Magnus.
The Iliacus Internus.
The Sartorius.
The Tensor Vaginæ Femoris.
The Quadriceps Extensor Cruris.

THE PSOAS MAGNUS.

The Psoas muscle arises from the border and the transverse process of the last dorsal and the first four of the lumbar vertebræ, and from the intervertebral tissues. The muscle possesses a soft fleshy belly broader behind than in front, and forms at the sacro-iliac junction a conspicuous tendon which passes beneath Poupart's ligament to be inserted into the femur at the trochanter minor. The tendon is joined laterally just before its insertion by the fibres of the Iliacus Internus muscle.

The muscle arises from tendinous arches at the side of the bodies of the vertebræ rather than from the bones themselves, and may secure additional origin by minute slips from the costo-transverse ligaments.—The fascicles from the transverse processes are more pronounced above than below.

A distinct accessory bundle, known as the Psoas Parvus, arises from the transverse processes of the upper lumbar vertebræ, and is inserted by a distinct tendon into the tendon of the main muscle. It is often absent.

Another slip, named the Psoas Minor, arises from the transverse processes of the last dorsal and the first lumbar vertebræ, passes along the inner border of the main muscle, and is lost in the iliac fascia at the border of the true pelvis.

Use.—To flex the femur upon the pelvis. The muscle cannot produce this movement without turning the femur from within slightly outward. When acting with the anterior portion of the two smaller Glutei muscles, it swings the limb not merely forward, but slightly outward.

Nerves.—These are derived from the third lumbar nerve.

Variations.—The Psoas and the Iliacus Internus may be distinct throughout. The Psoas may arise from all the lumbar vertebræ. This origin is given as the normal one by Cruveilhier.

Remarks.—The deep position of the Psoas muscle in the abdomen and the thigh, as well as the yielding character of the tissues about it, determine the form and direction of a clot, or of an abscess occurring in the neighborhood of the muscle or in its substance. Inflammation within the muscle is frequently excited by contiguous disease of the lumbar vertebræ, or, more rarely, by infiltration of the connective tissue about the kidney. An infrequent cause is rupture of some of the fibres of the muscle by violent over action. It is well known that, after death, the fibres of the Psoas are often lacerated by rough handling of the subject. It is possible, therefore, to conceive of laceration of the muscle by blows even when the muscle is at rest.

In a case reported by J. W. Grosvenor,[1] a few of the anterior fibres of this muscle were ruptured—a lesion which was followed by suppuration. The pus burrowed behind the muscle, and thence passed upward to a point between the stomach and liver, where it opened into the peritoneal cavity.

R. G. Butcher[2] found, in the case of a girl six years old, who perished by a venous hemorrhage into the sac of an old psoas abscess of the right side, that the clot occupied the iliac fossa, extending upward within one inch of the origin of the Psoas muscle, and downward along its course beneath Poupart's ligament, where it seemed to bifurcate; one branch of the coagulum lay beneath the conjoined tendon of the Psoas and Iliacus Internus muscles, and thence expanded so as to fill the entire sac of the abscess in the thigh; the other (being comparatively superficial) was situated to the inner side of the Sartorius muscle between i and the femoral vessels. The clot was defined infe riorly by the point where the Sartorius crosses the thigh. The position and limitation of the clot in the thigh illustrated the yielding character of the connective tissue in Scarpa's triangle as well as its continuity with the retro-peritoneal space.

Examples of pus following a similar course are not infrequent. The pus may lie in front of the muscle, and thence gravitate toward its insertion. It may form a rounded mass in the iliac fossa, or upon reaching the thigh may form a fluctuating mass to the outer side of Poupart's ligament and beneath the fascia lata. Dr. Gordon Buck[3] collected a number of illustrative cases of this phase of abscess, in none of which spinal disease existed. The Iliacus muscle was thought to be more intimately related to the abscess than was the Psoas. In females the exciting cause of the collection may be in an inflammation of the pelvic organs and of the connective tissue about them.

John Hilton[4] describes an abscess occurring be-

[1] N. Y. Med. Record, Dec. 2, 1867.
[2] Essays and Reports on Oper. and Conserv. Surg., Dublin, 1865, 340.
[3] N. Y. Journ of Medicine, 1857, 147.
[4] Lancet, Nov. 1860, 455; also Lectures on Rest and Pain.

neath the Iliacus, which descended into the thigh behind the tendon, and thence behind the femoral vessels in front of the hip-joint and toward the inner part of the thigh. In rare instances, the pus, after being guided by the common tendon its entire length, passes to the outer side of it, and collects beneath the Tensor Vaginæ Femoris and the anterior portion of the Gluteus Medius muscle.

Instead of following the course of the muscle beyond the pelvis, the pus may rupture the sheath and empty into the abdominal cavity, as in the case mentioned above. It may, indeed, rupture in more than one direction, pus passing downward behind the muscle as well as anteriorly into the abdomen. Mr. T. Holmes[1] reports a lesion of this kind in a boy eight years old.

Contracture of the Psoas may be excited by the presence of pus either within or alongside the muscle. In perinephritic abscess the value of this sign was determined by Bowditch;[2] while Benjamin Lee[3] invited attention to it in psoas abscess pointing at the groin.

In contracture the patient inclines the body forward when standing, and thus relieves the weight of the body upon the affected side. The heel is slightly raised, the toes alone touching the ground. Under these circumstances the vertebral column in the lumbar region is deeply curved forward, but without projection above, or it inclines from the affected side.

The bursa beneath the tendon of the Psoas and the Iliacus, when inflamed, may counterfeit disease of the hip-joint. In a case occurring under the care of the writer, an obscure flattened swelling existed over the joint, associated with local pain, lameness, and wasting of the affected limb. The swelling was believed to be due to an inflammation within the bursa.

THE ILIACUS INTERNUS.

The Iliacus Internus muscle arises from that portion of the iliac fossa which is bounded in front by a line from the anterior superior spinous process to the notch beneath the anterior inferior spinous process, as well as from the anterior two-thirds of the inner lip of the crest. It also arises from the sacro-iliac juncture, from the ilio-lumbar ligament and base of the sacrum, as well as from the anterior surface of the capsule of the hip-joint. From this extensive surface the fibres converge to be inserted, while still for the most part fleshy, into the lateral border of the tendon of the Psoas Magnus. It occupies the groove between the anterior inferior spinous process and the ilio-pectineal line. The fibres at this point are somewhat twisted. The lower ones have a distinct insertion into the trochanter minor. Beneath the common tendons of the two muscles there is a large bursa, which may communicate with the hip-joint.

Use.—See functions of Psoas Magnus.

Nerves.—These are derived from the main trunk of the anterior crural nerve.

Variations.—The lowest fibres are sometimes separate from the main muscle. They then arise from the anterior inferior spinous process and the anterior portion of the capsule, and are inserted into the trochanter minor.—The bursa is the largest in the body. It is oftener found to communicate with the joint in the aged than in the young. A second smaller one, *bursa iliaca*, is found beneath the tendon.

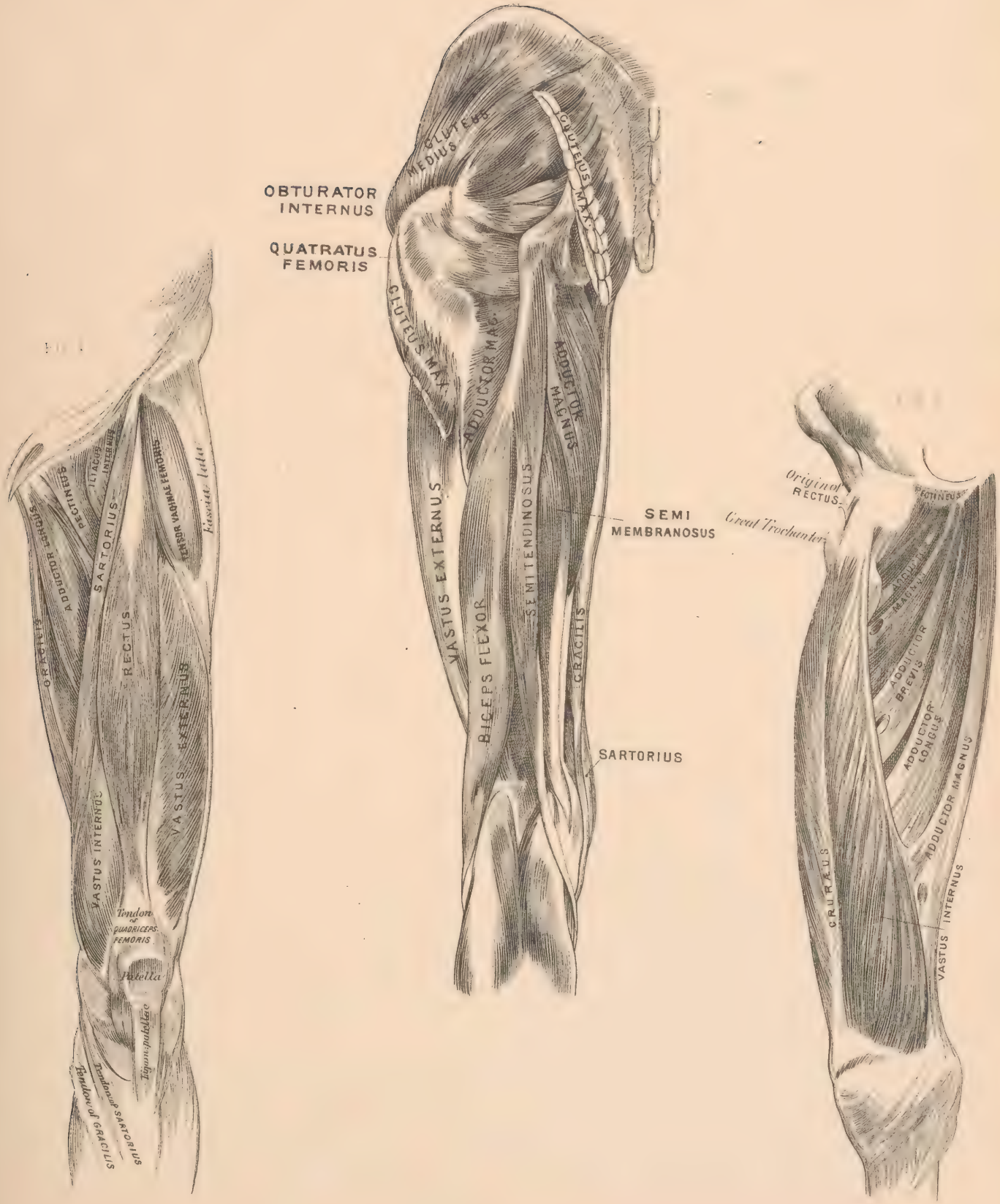
THE SARTORIUS.

The Sartorius muscle arises from the anterior superior spinous process of the ilium and from a small portion of the adjacent bone. The long ribbon-shaped muscle passes downward and inward, crossing the front and gaining the inner side of the thigh, along which it descends nearly vertically on a line with the posterior margin of the internal femoral condyle. At this point it becomes tendinous, and, crossing the knee-joint, turns slightly forward, and is inserted by a broad thin tendon on the inner side of the head of the tibia and for a short distance below it. With the tendons of the Gracilis and the Semitendinosus, the Sartorius forms the broad aponeurotic sheet on the proximal inner surface of the leg; this sheet has received from French writers the name of *patte d'oie*.

[3] Med. Times and Gazette, Dec. 1862, 630.
[4] Boston Med. Surg. Journ., May 4, 1868.
[5] Trans. Med. Soc. Penna. 1876, 539.

EXPLANATION OF PLATE LIV.

Fig. 1. The muscles of the anterior surface of the thigh.
Fig. 2. The muscles of the buttock and those of the posterior surface of the thigh.
Fig. 3. The muscles on the median surface of the thigh.


OBTURATOR INTERNUS
QUATRATUS FEMORIS
GLUTEUS MEDIUS
GLUTEUS MAX.
GLUTEUS MAX.
ADDUCTOR MAG.
ADDUCTOR MAGNUS
VASTUS EXTERNUS
SEMITENDINOSUS
BICEPS FLEXOR
GRACILIS
SEMI MEMBRANOSUS
SARTORIUS
Great Trochanter
Origin of RECTUS
PECTINEUS
ADDUCTOR MAGNUS
ADDUCTOR BREVIS
ADDUCTOR LONGUS
ADDUCTOR MAGNUS
CRURAEUS
VASTUS INTERNUS
PECTINEUS
ILIACUS INTERNUS
ADDUCTOR LONGUS
SARTORIUS
TENSOR VAGINÆ FEMORIS
Fascia lata
RECTUS
VASTUS EXTERNUS
VASTUS INTERNUS
Tendon of QUADRICEPS FEMORIS
Patella
Ligam. patellæ
Tendon of SARTORIUS
Tendon of GRACILIS

T. Sinclair & S

Use.—The Sartorius muscle flexes the leg on the thigh, and the thigh on the pelvis. In the execution of these movements the femur is rotated slightly outward. In conjunction with the Gracilis, Semitendinosus, and Biceps muscles it assists in raising the foot from the ground, and may make tense the deep fascia of the leg.

Nerves.—The Sartorius receives branches of the middle cutaneous nerve, which enter on the median border by an imperfectly defined interlaminate space. A few distinct twigs from adjacent cutaneous nerves supply it further down.

The muscle, near its insertion, sends a fibrous slip to the capsule of the knee-joint and to the fascia of the leg. Two bursæ are found in relation with the tendon: one lies between the muscle and the internal femoral condyle; and the other lies beneath the *patte d'oie*.

Relations.—These, owing to the proximity of the muscle to the femoral artery, are important.—From its origin to a point on a hypothetical transverse line answering to the femoro-scrotal fold—a distance of about three inches—the muscle lies to the inner side of the Tensor Vaginæ Femoris, which protects and in a measure conceals it. It is crossed (sometimes pierced) by a branch of the middle cutaneous nerve. To the inner side (the thigh being extended) is the eminence of the head of the femur. Beneath lie the tendons of the Iliacus Internus and the Psoas. The muscle here lies well to the outer side of the sheath of the great vessels.—From the transverse line, at the point of chief nerve supply, to the inner side of the thigh, the muscle crosses the thigh obliquely. It here, at first, rests on the Rectus Femoris, and afterward on the Vastus Internus. Separated by a thick layer of deep fascia, it lies over the deep branches of the anterior crural nerve. It lies at first over and then to the inner side of the sheaths of the great vessels.—The remaining portion of the muscle in the thigh is nearly vertical, and lies in a deep sulcus defined by the Vastus Internus on the outer side, and by the Adductor Longus and Adductor Magnus muscles on the inner. The sheath of the great vessels is beneath the muscle above, and to the outer side below. Opposite the knee-joint and at its insertion it is in advance of and above the Gracilis and the Semitendinosus.—Beneath the muscle, near its insertion, is the long saphenous nerve.

When the head of the femur is drawn down, these muscles are relaxed, and the finger can be pushed in the hollow between them.

Variations.—It rarely presents a transverse inscription. Its belly may divide—one portion going to the posterior ligament of the knee-joint, or both portions going to the tibia; or a portion may be lost over the fascia of the Vastus Internus, or be inserted upon the femur.

THE TENSOR VAGINÆ FEMORIS.

This muscle arises from the anterior superior spinous process, and from the notch lying beneath, as well as from the anterior portion of the crest of the ilium. It forms a quadrilateral or triangular figure situated at the upper third of the thigh between the Sartorius and Gluteus Maximus muscles, with the latter of which it is intimately associated. It is inserted into the fascia lata at the junction of the upper with the middle third of the thigh.

Use.—The muscle first makes the fascia lata tense, in which act it is aided by the Gluteus Maximus. It exerts no appreciable influence in extension of the thigh, but induces to a limited extent flexion with rotation from without inward. It may thus turn the toes slightly inward when the foot is extended. The degree of this rotation is about equal to that effected by the Psoas. The thigh being fixed, the muscle can slightly aid in flexing the pelvis.

Nerve.—This is derived from the inferior branch of the superior gluteal.

The Variations of the Tensor Vaginæ Femoris are unimportant.

According to Barwell, the muscle can rotate the flexed leg outward.—Maissiat and H. Meyer consider the portion of the fascia lata lying between the Tensor and the tibia to be equivalent to a prolonged tendon of the former; the muscle has thus received the name of the Ileo-Tibiale. In emaciated individuals the tibial attachment of the fascia answering to this so-called tendon is sufficiently prominent to produce for a short distance above the tibia a ridge-like elevation of the skin.

THE QUADRICEPS EXTENSOR.

This muscle, as the name implies, is composed of four more or less distinct portions, namely, the Rectus Femoris, the Vastus Externus, the Vastus Internus, and the Crureus. The Rectus is of pelvic origin, the remaining three are femoral. The numerous fibres of the muscle all converge to act upon the patella, which may be considered to be a sesamoid bone within a tendon; this tendon, under the name of the ligamentum patellæ, is inserted into the tibia at the anterior tuberosity. The common tendon is received upon the front of the oblique proximal border of the patella.

The *Rectus Femoris* arises tendinously from the anterior inferior spinous process of the ilium, and by a distinct horizontal slip from the superior part of the

rim of the acetabulum. The muscle passes directly downward upon the front of the thigh, and is inserted by a broad thin tendon upon the upper portion of the patella.

The muscle is to a slight degree bi-laminate near its origin, and is obscurely bi-penniform at the upper anterior portion of its belly. Near the insertion it is fleshy, the fibres being nearly vertical. The tendon of origin resembles a ligament, and is free at the inner border. It runs down within the muscle at the upper third.—The acetabular head joins the main tendon at right angles, and is not free inferiorly, being here continuous with a thin aponeurotic slip which passes downward.—The posterior surface of the muscle is fibrous for its entire length.—The lower two-thirds of the posterior surface of the tendon of insertion receives at its outer edge the superficial fibres of the Vastus Externus, and to a much less extent receives muscular fibres from the Vastus Internus.

Relations.—The Rectus is the most isolated of the divisions of the Quadriceps. It lies superficial to them all in a groove between the two Vasti, and upon the Crureus.—In front, at its origin, are the Psoas and the Sartorius. Lower down, the fascia and the integument. In front of the acetabular tendon is the Gluteus Minimus. To the outer side are the Tensor Vaginæ Femoris and the Vastus Externus. To the inner side are the Vastus Internus, the Sartorius, and the Psoas. Behind lie the capsular ligament of the hip-joint, the Psoas, and the Crureus; between these and the muscle pass obliquely the external circumflex artery and a branch of the anterior crural nerve.

The entire muscle lies within a sheath of fascia, the anterior portion of which is the thicker.

The *Vastus Externus* arises from the base of the great trochanter, from a line leading thence outward and downward to the linea aspera, from the entire length of the outer lip of the linea aspera, and by short dispersed fleshy slips from the posterior surface of the sheath of the muscle at the lower third. In addition to these it derives fibres from the intermuscular septum between it and the short head of the Biceps Femoris, and from the posterior aspect of the femoral tendon of insertion of the Gluteus Maximus.

The muscle is inserted into the outer side of the patella and into the tendon of the Rectus Femoris. It forms a large fleshy mass extending along the entire length of the thigh upon its outer side, and is for the most part on a plane above that of the Vastus Internus and the Crureus, but below that of the Rectus Femoris. It is continuous with the Crureus at its posterior border, and joins the Rectus tendon below.

The fascia lata is properly not connected with the muscle. It is held to the muscle, it is true, by a tough layer of connective tissue, but presents no organic union. This union is firmer at the upper half of the muscle posteriorly than elsewhere. The intermuscular septum between it and the Biceps Femoris is pierced here and there by twigs of bloodvessels.

The muscle is fleshy externally and fibrous internally at its lower half or two-thirds, where it lies in contact with the tendinous surface of the Crureus. The fleshy slips from the sheath below are arranged for the most part external to a central shining tendon, very much in the manner that the superficial fibres of the Temporal muscle are disposed in relation to their tendon.

The *Vastus Internus* arises from an oblique line running from the front of the base of the neck of the femur to the linea aspera, from the internal lip of the same to the middle of the shaft, and from the tendon of insertion of the Adductor Magnus (internal intermuscular septum). The muscle forms a pyriform mass, having its apex above, and is inserted upon the inner border of the patella, and the corresponding border of the tendon of the Rectus Femoris.

The fibres are fleshy, and are upon the same plane as those of the Crureus. Those from the linea aspera are slightly tendinous. The upper muscular fibres are oblique; the lower nearly horizontal.—A fibrous layer, continued over the great vessels and the long saphenous nerve at the middle third of the thigh, is directed from the Vastus Internus to the Adductor Magnus, and forms the anterior boundary of Hunter's canal.

The Crureus is continuous with the preceding, and the two may be said to form one great mass. They are separated for convenience in description. W. Roger Williams[1] describes the Crureus as composed of four laminæ, each of which arises separately from the femur. The Subcrureus may be looked upon as a rudiment of a fifth lamina.

Relations.—In front are the Sartorius and branches of the anterior crural nerve; some of the latter penetrate the upper border of the muscle. The great vessels also lie in front. Near the knee the muscle lies beneath the fascia and skin. Behind lie the femur, and the tendons of insertion of the Adductor Longus and the Adductor Magnus. To the outer side are the Rectus Femoris and the Crureus. To the inner side are the femoral vessels, the Adductor Longus, and the Adductor Magnus.

The *Crureus* arises by fleshy fibres from the anterior and outer aspects of the shaft of the femur. It is more or less identified with both Vasti, particularly with the Vastus Internus. It is covered in front and to the outer side by the Vastus Externus, and along its inner border it is continuous with the fibres of the Vastus Internus which are on the same plane with its own. The muscle is inserted upon the upper border and sides of the patella.

[1] Journ. of Anat. and Phys., 1870.

The anterior surface at its lower two-thirds is fibrous.

Relations.—In front the Rectus Femoris and the Vastus Externus. To the inner side the Vastus Internus, and to the outer side the Vastus Externus. Behind it is the shaft of the femur.

The *Subcrureus* is a name given to a delicate bundle of fibres arising by fleshy slips from the anterior surface of the shaft of the femur a short distance above the patella, and descending thence to be inserted into the synovial pouch of the knee-joint.

Use.—When all the parts of the muscle act together, the leg is extended upon the thigh. In addition to the above action the Rectus aids in holding the head of the femur against the acetabulum when the body is erect. Its atrophy causes great difficulty in walking. To relax the Rectus the hip must be elevated and the knee extended.

The Vastus Externus draws the patella upward and outward. Its strength is greater than that of the Vastus Internus, which draws the patella upward and inward. When both act the patella ascends, aided by the Rectus and the Crureus. Dislocation of the patella is ordinarily outward, a fact readily explained by the greater strength of the Vastus Externus. It may be induced by rapid walking, jumping, dancing, etc., or by powerful contraction under electricity.

The Subcrureus makes tense the synovial prolongation beneath the tendon.

Nerve.—The Quadriceps Extensor is supplied by the anterior crural nerve.

As the extensions downward of the fascia lata reach the region of the patella they secure additional strength by union with fleshy fibres of the two Vasti muscles. Thus increased strength is secured to the sides and front of the knee-joint, and more or less influence, besides that directly secured through the line of its main tendon, is exerted upon the leg by the contraction of the Quadriceps.—A bursa lies beneath the aponeurosis over the patella; and another is seen lying between the skin and the aponeurosis directly over the first-named bursa.—A third bursa lies between the ligamentum patellæ and the tibia.

Remarks.—The Ligamentum Patellæ often furnishes signs of great value in the study of disease and injury. R. Cleemann found its relaxation and the wrinkling of the integument over it to be characteristic of fracture of the neck of the femur.—Any deviation of the tendon from the vertical line indicates, according to Holden, displacement of the tibia. The ligament is best seen in semi-extension, the foot being unsupported. When in this position, as when one sits with the limb under observation thrown over the knee of the limb of the opposite side, a smart blow is struck directly over the ligament, the patella, or the muscle directly above this bone, the leg and foot are perceptibly extended. This movement, which has received from Erb the name of "patellar tendon reflex," is absent as a rule in locomotor ataxia.[1]

The Ligamentum Patellæ can suffer spontaneous rupture, as shown in the following case: A man, aged thirty-one, in attempting to save himself from a violent fall backward, ruptured this tendon. The knee swelled after the accident and became painful, the patella being drawn up an inch.[2]

The entire muscle may undergo partial atrophy or loss of tone after fracture of the patella.[3]—The Rectus Femoris may be ruptured[4] or undergo atrophy in chronic contracture of the Biceps Flexor in children (Duchenne).

The Internal Femoral or Adductor Muscles.

The muscles of this group embrace—

The Gracilis.
The Pectineus.
The Adductor Longus.
The Adductor Brevis.
The Adductor Magnus.

THE GRACILIS.

This muscle arises by a thin broad tendon from the pubis close to the suspensory ligament of the penis, and from the entire border of the descending ramus of the pubis. It passes down the inner side of the thigh, and becomes tendinous at about the middle or lower third to form a rounded tendon which passes downward parallel with the Sartorius, below the internal condyle, where it is expanded into a broad aponeurosis to be inserted into the median surface of the shaft of the tibia. A bursa lies between the muscle and the internal lateral ligament.

Use.—The Gracilis adducts the thigh, flexes the leg upon the thigh, and rotates the thigh from without inward.

Nerve.—The Gracilis is supplied by the obturator nerve.

Relations.—The muscle is subcutaneous. To the outer side lie the Adductor Brevis, from which it is separated by fascia, and the Adductor Magnus. At the lower third of the

[1] See G. Steward, Med. Times and Gazette, Jan. 1878, and W. R. Gowers, Medico-Chirurgical Trans., 1879, 269.

[2] Bryant's Surgery, 901.

[3] Jonathan Hutchinson, Med.-Chir. Trans., lii. 340.

[4] Sédillot, Mém. et Prix de la Soc. de Méd. de Paris, 1817.

thigh the Sartorius lies to its inner side and in front. To the outer side, from the middle of the thigh, lies the Semimembranosus.

The Gracilis is singularly constant.

THE PECTINEUS.

The Pectineus muscle arises from the entire length of the crest of the pubis, from the pubic spine, and in part from Gimbernat's ligament. A deep fasciculus arises from the upper border of the obturator foramen and from the space between it and the base of the spine of the pubis. The muscle passesdownward and slightly outward, gradually entering a plane deeper than that of its origin, and is inserted by a broad thick tendon into the femur on a line extending from the beginning of the linea aspera (spina trochanterica minor) to the lesser trochanter.

The muscle is covered at its origin by a well-defined fascia, which is continuous with the fascia lata, and from which some of the muscular fibres arise. The tendon of insertion is smooth and aponeurotic. The muscle is fleshy above, where it may be readily torn by rough handling; but is firmer and more aponeurotic near the insertion. It is entirely fibrous where it lies in contact with the trochanter minor.

The muscle may be divided into two layers, more or less perfect above, the superficial and the deep. The superficial or flat portion (supplied by a branch of the anterior crural nerve) is that described as arising from the pubic bone. The deep or slender portion (supplied by a branch of the obturator nerve) is that seen arising from the upper border of the obturator foramen. A well-defined layer of fascia separates the two portions. This division is maintained in some lower animals.

Relations.—In front lie the femoral vessels and the fascia lata. Beneath, separated by a well-defined fascia, are the obturator artery and nerve, and the External Obturator and Adductor Brevis muscles. To the outer side is the Psoas Magnus, to the inner is the Adductor Longus. A small muscular artery, an ascending branch of the internal circumflex, often runs upward along the inner border of the muscle. —The tendon is applied directly to the trochanter minor in rotation inward, and is in contact on its inner side with the tendon of the Adductor Brevis.

Use.—To draw the femur inward and forward as in crossing the limbs. It is thus a flexing adductor.

Nerve.—The muscle is supplied by the obturator and anterior crural nerves.

Variations.—The muscle may receive a slip from the Adductor Longus and Iliacus Internus, as well as send a slip to the Obturator Externus and the capsule of the hip-joint.—It may join the Iliacus Internus in its insertion at the trochanter minor. A slip may pass in front of the femoral vessels.

THE ADDUCTOR LONGUS.

This muscle arises tendinously from the pubic bone between the spine and the symphysis. It is a flat fleshy muscle whose edge is turned upward and inward, and passes downward and outward, becoming broader as it does so, to be inserted by a flat, thin tendon into the femur at the middle third of the linea aspera. The tendon unites with the Vastus Internus and with the tendon of the Adductor Magnus. It sends a slip to the Adductor Magnus.

The tendon of origin is robust, and resembles a ligament. It is produced along the inner border for a short distance, but thence to about the middle of the muscle (where it disappears) it is concealed.—The tendon of insertion is aponeurotic. Three layers of tendinous fibres are seen at the insertion; one anterior, one posterior, and one intermediate.

Relations.—In front, and to the outer side, lie the femoral vessels, a portion of the Sartorius muscle, and a thinned extension of the fascia lata. Behind it lie the Adductor Brevis, and below, the Adductor Magnus, with which it is continuous. To the outer side, above, and on a deeper plane is the Pectineus. To the inner side, above, lies the Gracilis.—The Adductor Longus forms the inner side of Scarpa's triangle.—After the fascia lata has been cut through along the subcutaneous surface of this muscle the finger can isolate the Adductor Longus from the contents of the triangle, and roughly define the branches of the profunda femoris as they enter the Adductor group of muscles.

Use.—To adduct the femur and thus to assist the other muscles of its group.

Nerve.—The muscle is supplied by the obturator nerve.

By abducting the thigh the tendon of the muscle is made tense and prominent, and, in this condition, has been claimed by Holden to be a useful guide to the spine of the pubis, and this in turn to the position of the external abdominal ring. Hancock[1] mentions three instances of rupture of this muscle occurring as a result of sudden and violent contraction attending the effort of riders to retain their seats on jumping or lunging horses. The tendon of origin is often divided subcutaneously by the surgeon for contracture accompanying hip-joint disease.

Variation.—It may undergo cleavage throughout, both longitudinal and planal. It may receive an accession from the Pectineus.

THE ADDUCTOR BREVIS

muscle arises from the base of the pubic spine and from the entire length of the descending ramus at the symphysis. It forms a thick stout belly, which is

[1] Anat. and Surg. of Human Foot, 1873, 99.

directed downward and outward, slightly increasing in breadth, and is inserted into the inner lip of the linea aspera, or into a line extending thence to the inner side of the base of the trochanter minor.

Use.—To adduct the femur.

Nerve.—This is derived from the obturator nerve.

Relations.—The muscle lies beneath the Adductor Longus and the Pectineus, and a small portion of the Gracilis, and the anterior branches of the obturator vessels and nerves, which lie on this muscle rather than in the space between it and the Adductor Longus.

The muscle, from its origin at the pubic spine, is fleshy, and at its origin from the descending ramus of the pubis it is thin and aponeurotic. At the insertion the upper portion is tendinous and aponeurotic, the remaining portion is fleshy. —A few fibres of the muscle may arise from the under surface of the origin of the Gracilis.

Variations.—The muscle may fuse with the Adductor Magnus. It may be divided into two or three parts.

THE ADDUCTOR MAGNUS.

The Adductor Magnus muscle arises from the descending ramus of the pubis, from the ascending ramus of the ischium, and by a robust bundle of fibres from the anterior portion of the tuberosity of the ischium. The fibres pass for the most part downward and outward, and are inserted into the entire length of the median lip of the linea aspera below the Quadratus Femoris.

Use.—The Adductor Magnus is the main adductor of the thigh. Its lower part rotates the femur inward. Atrophy of this portion causes the foot to turn a little outward when the limb hangs vertically. When the action of the Adductor Magnus and of the Adductor Brevis and Adductor Longus is suspended, the limb swings a little obliquely outward during the second movement of the act of walking.

Nerves.—These are derived from the obturator nerve and from short branches of the great sciatic.

The fibres which arise from the pubis and the front part of the tuberosity pass horizontally outward, and are inserted into a line extending from the middle of the intertrochanteric line to the linea aspera. Those arising from the inferior margin of the pelvis and the ischial tuberosity pass downward and outward to be inserted into the linea aspera for its entire length, into its inner lip below, and by a vertical slip into the tubercle at the inner margin of the shaft near the inner condyle; and also to be attached at the lower third of the femur together with the Vastus Internus muscle and the internal intermuscular septum.—The muscle is pierced by the femoral vessels at the lower third, elsewhere by the perforating arteries.—The ischial origin is conspicuously fibrous posteriorly.

Luschka describes the fibres of the muscle as spiraliform.

According to Sappey, a bursa underlies the horizontal fibres as they pass over the trochanter minor.—H. Meyer[1] proposes for that portion of the muscle pierced by the branches of the profunda femoris artery the name Adductor Perforatus.

Relations.—In front are the Adductor Longus, the Adductor Brevis, and the femoral artery and nerve. At the middle third, and thence to the lower third, is the long saphenous nerve. A large branch of the profunda lies in front of the upper half. Behind lie the hamstring muscles and the great sciatic nerve. Behind, and to the outer side at the lower third, are the femoral head of the Biceps, and the popliteal artery and vein. The femoral sheath passes rather between the median and lateral divisions than through the muscle. The cord-like tendon, below the point of entrance of the femoral artery, is crossed by several of the cutaneous nerves.

Variations.—The muscle may fuse with the Quadratus Femoris. Horizontal cleavage may in great part separate the median fibres, which are inserted into the femoral condyle, from the lateral, which are inserted into the linea aspera.

Muscles of the Leg and the Foot.

The muscles of the anterior region of the leg and the foot include—

The Tibialis Anticus.
The Extensor Proprius Pollicis Pedis.
The Extensor Longus Digitorum Pedis.
The Peroneus Tertius.
The Extensor Brevis Digitorum Pedis.

THE TIBIALIS ANTICUS.

The Tibialis Anticus muscle arises from the proximal two-thirds of the lateral surface of the shaft of the tibia, from the tibial tubercle, from the septum between the muscle and the Extensor Longus Digitorum, from the fascia of the leg, and from the interosseous membrane. The muscle is pyriform; the stout tendon becomes free at about the middle of the leg, and passes at first vertically downward, then obliquely across the front of the leg beneath the annular ligament, to be inserted at the tubercle of the first cuneiform bone and at the proximal end of the first metatarsal bone. The muscle is superficial throughout. The tendon lies in a loose synovial sheath, and, owing to the circumstance that the annular ligament lies loosely over it, is, in the living subject, the most conspicuous of all the tendons crossing the front of the ankle.

Use.—To flex the foot and at the same time to rotate it a little inward on its longitudinal axis so

[1] Anatomie; also Zeit. für Anatomie und Entwickelungsgeschichte, 1876, 29.

that the median border is somewhat elevated. In conjunction with the Extensor Longus Digitorum and the Extensor Proprius Pollicis the muscle flexes the foot only. In the act of riding, the Tibialis Anticus assists in maintaining the foot in the stirrup. The muscle is antagonized by the Peroneus Longus.

Nerve.—It is supplied by the anterior tibial nerve.

The Tibialis Anticus is greatly compressed from side to side, being widest at the superficies of the leg and narrow at the interosseous membrane.—A fibrous slip passes from the tendon of insertion to strengthen the ligaments at the median border of the foot.—A bursa lies beneath the tendon of insertion.

Remarks.—In *talipes varus* the tendons of the Tibialis Anticus, and of the muscles which extend the toes as they lie in front of the ankle-joint, incline to the median side of the leg; and the tendon of the Tibialis Anticus as it crosses the joint is placed in a marked degree to the same side. In pronounced cases the tendon passes obliquely downward across the inner malleolus and inclines backward toward the first cuneiform bone.—In the adult, the subject of *talipes varus*, the tendon of this muscle passes obliquely downward and backward on the surface of the inner malleolus, and takes a curved direction inward and backward to its insertion. As the tendon crosses the ankle-joint it passes in an oblique direction from the inner malleolus behind rather than in front of the process. This, in the judgment of Mr. Adams, is an exceedingly important point, since the tendon in a normal foot is found below and in front of the inner malleolus.

L. A. Sayre[1] found atrophy of the Tibialis Anticus associated with contracture of the peroneal muscles.

Variations.—The muscle may undergo partial cleavage. The tendon may be rarely inserted into the neck of the astragalus, but more frequently into the first metatarsal bone. A slip may join the Extensor Brevis Digitorum Pedis, or the Extensor Proprius Pollicis Pedis. A fascicle may be separated from the anterior portion of the muscle, which (or a fibrous slip from its tendon) is inserted either into the annular ligament or the fascia dorsalis pedis. This slip is probably related to the more anterior of the two anterior tibial muscles of Echidna.

Relations.—In the leg the Tibialis Anticus lies upon the tibia, upon the interosseous membrane, upon the proximal portion of the Extensor Proprius Pollicis, and to a less extent upon the Extensor Longus Digitorum. To the median side are the tibia, and to the lateral the Extensor Proprius Pollicis. Between the muscle and the Extensor Proprius Pollicis are the anterior tibial vessels and nerve. At the ankle the tendon lies directly beneath the integument to the median side of the anterior tibial vessels and nerve.

[1] Orthopædic Surgery and Diseases of the Joints, 64.

THE EXTENSOR PROPRIUS POLLICIS PEDIS.

The Extensor Proprius Pollicis Pedis muscle arises from the middle two-fourths of the narrow anterior border of the fibula, but secures most of the fibres from the interosseous membrane. Its fascicles are directed obliquely forward and downward, and the tendon, passing beneath the annular ligament in a distinct compartment, is inserted into the second phalanx of the first toe.

Use.—To extend the first toe.

The muscle is distinctly penniform, the tendon lying anteriorly.

Variations.—The muscle may undergo longitudinal cleavage. It may send a slip to the Extensor Communis Digitorum. A delicate fascicle, as a rule, is sent from the inner border of the tendon, at its insertion, to be inserted on the base of the first phalanx of the great toe at the side of the metatarso-phalangeal joint. A bursa commonly underlies the tendon at the instep.

Nerve.—The nerves are derived from the anterior tibial nerve.

Relations.—The muscle lies in a sulcus between the Tibialis Anticus and the Extensor Longus Digitorum. In front of the ankle it crosses the anterior tibial vessels and nerve. On the dorsum of the foot it overlies some of the deeper veins, and, along the median border, the dorsal ligaments.

EXTENSOR LONGUS DIGITORUM PEDIS.

The Extensor Longus Digitorum Pedis muscle arises from the head and the proximal three-fourths of the

EXPLANATION OF PLATE LV.

Fig. 1. The muscles on the lateral and anterior surfaces of the leg and the foot.

Fig. 2. The muscles of the ham and the posterior surface of the leg.

Fig. 3. The same, showing a deeper layer of the muscles of the leg.

Fig. 4. An additional study of the muscles on the median surface of the thigh.

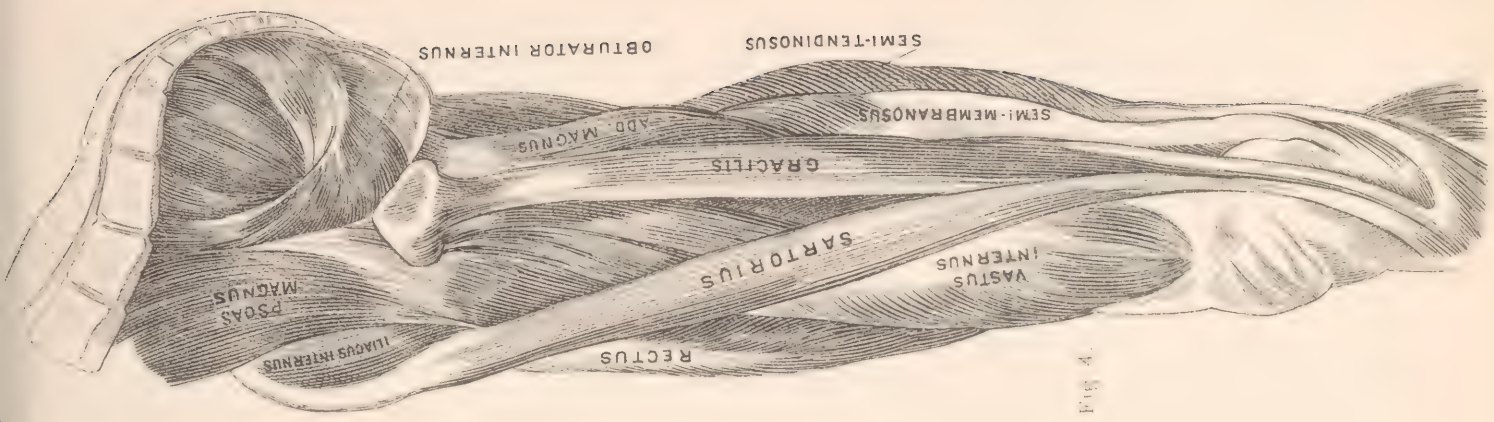


Fig 4

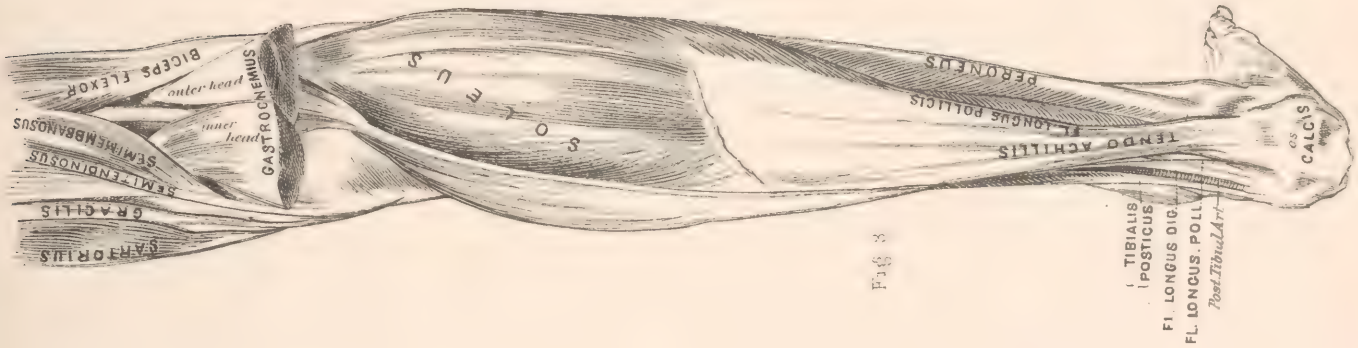


Fig 3

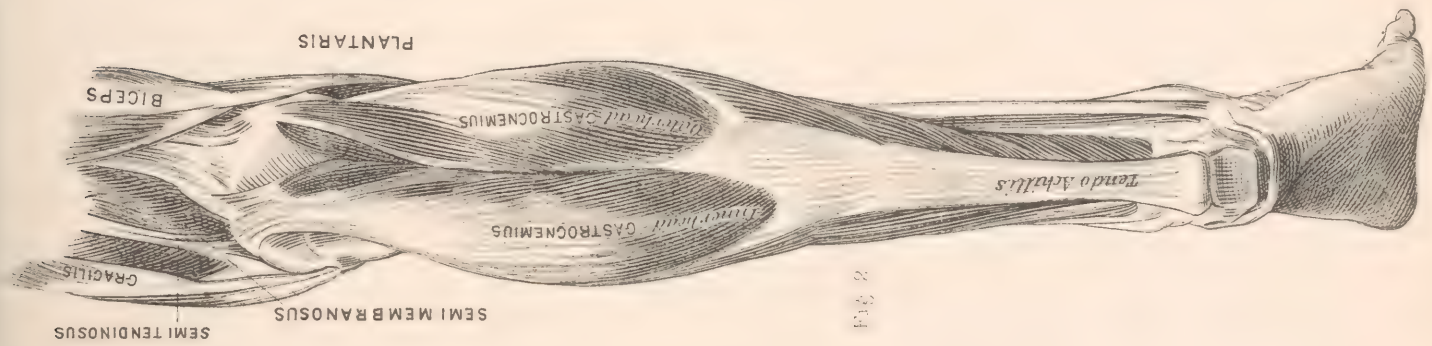


Fig 2

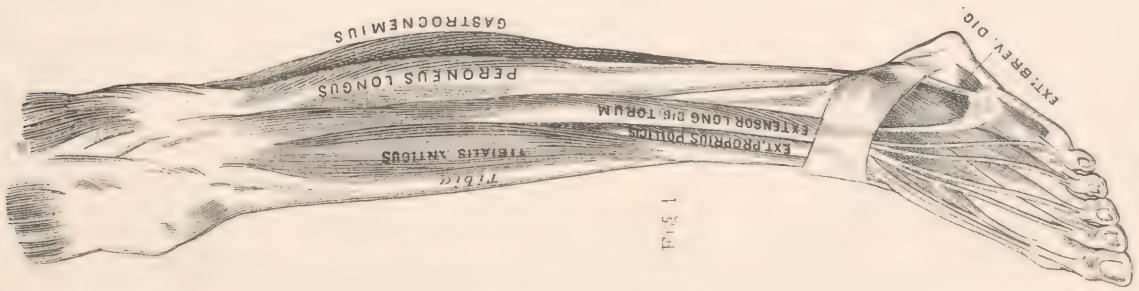


Fig 1

T. Sinclair & Son, Lith.

anterior border of the fibula, from the external tuberosity of the tibia, from the fascia of the leg, from the septum between the muscle and the Tibialis Anticus, and from the septum between the muscle and the Peroneus Longus and the Peroneus Brevis. An important accession is secured from the interosseous membrane. The tendon passes beneath the annular ligament, sometimes in a sheath in common with that of the Extensor Proprius Pollicis, but oftener in a separate compartment, to reach the dorsum of the foot, where it divides into four tendons which are inserted on the dorsal aponeuroses of the second, third, fourth, and fifth toes. Each of the tendinous expansions receives the tendons of insertion of the Interossei and Lumbricales muscles.

Use.—To extend the four outer toes and to abduct and to flex the foot. Acting with the Tibialis Anticus the muscle flexes the foot. The foot is flexed and adducted, or abducted, according to the action of the other muscles. When the Gastrocnemius and the Soleus are atrophied, the Extensor Longus Digitorum, acting in conjunction with the Peroneus Longus, barely brings the foot to a right angle with the leg.[1]

Nerves.—The muscle is supplied by numerous small nerves from the anterior tibial nerve; these for the most part pierce the Extensor Proprius Pollicis for the purpose. A separate long nerve from the same source supplies the deep surface of the muscle.

At its origin the muscle is fusiform at the anterior border, but soon becomes penniform—the tendon lying at the anterior border—and is compressed laterally.—Each tendon splits into three slips at the base of the first phalanx. The median slip is inserted into the lateral edge of the second phalanx; the remaining slips unite upon the dorsal surface of the second phalanx, and are inserted upon the lateral border of the third phalanx.[2]

The tendon of the Extensor Longus Digitorum for the second and fourth toes is free at the lower third of the leg. It can be traced within the muscle as far as the upper fifth. The tendons for the fifth toe and fifth metatarsal bone (Peroneus Tertius) are distinct from the above and less extensive. Each of the tendons, excepting the last, is joined laterally by a tendon of the Extensor Brevis Digitorum.—Two bursæ are sometimes seen in connection with the Extensor Longus Digitorum, one lying beneath the annular ligament at the lateral edge of the tendons, and another between the tendons and the head of the astragalus.—The Extensor Longus Digitorum and the Extensor Brevis Digitorum are often rudimentary, or in a state of fatty degeneration, in congenital *talipes varus*.

Variations.—Partial longitudinal cleavage may separate the fibular and the tibial slips.—The remaining variations pertain to the tendon of insertion. A tendon may be inserted on the first toe. A slip may pass to the first phalanx of the second toe, and to the fifth metatarsal bone. Slips may be derived from the Flexor Brevis Digitorum and from the Peroneus Brevis. The tendon to the fifth toe may be duplicated. The muscle may arise from the fibula for its entire length.

The so-called Peroneus Tertius may fuse with the proper Extensor Longus Digitorum. It may be absent, when the latter muscle takes its place. The slip to the fifth toe may be absent. The muscle may send a slip to the Extensor Brevis Digitorum.

Relations.—To the lateral side is the Peroneus Longus. To the median side, near the proximal third of the leg, lie the Tibialis Anticus, and in the middle third the Tibialis Anticus and the Extensor Proprius Pollicis. The latter underlies the Extensor Longus Digitorum in great part as well. At the ankle the tendons overlie the anterior tibial vessels and nerve. The tendon of the Extensor Proprius Pollicis lies to the median side. On the dorsum of the foot the tendons overlie the Extensor Brevis Digitorum.

THE EXTENSOR BREVIS DIGITORUM PEDIS.

This muscle arises from the upper and outer surfaces of the anterior portion of the calcaneum. It receives an accession from the anterior annular ligament. It crosses the dorsum of the foot obliquely, and divides into four slips which end in delicate tendons and are inserted into the four inner toes. The slip to the great toe is larger than the others, and its tendon is attached to the proximal extremity of the first phalanx. The remaining tendons are inserted into the lateral borders of the tendons of the Extensor Longus Digitorum. A bursa lies near the sinus tarsi beneath the muscle.

Use.—To extend the toes. The muscle is secondary in its action to the Extensor Longus Digitorum. Its oblique direction from without inward counteracts the inward traction of the long extensor, the tendons of which lie on the dorsum of the foot obliquely from within outward.

Relations.—The groove for the Peroneus Brevis lies behind the line of origin of the muscle.

Nerve.—It is supplied by the anterior tibial nerve.

Some of the fibres of origin can be traced in the *sinus tarsi* to the interosseous astragalo-calcaneal ligament. Other fibres may arise from the superior calcaneo-cuboid ligament.

[1] Duchenne, Physiologie des Mouvements.

[2] THE PERONEUS TERTIUS.—Under this head some authors give the following arrangement of fibres of the Extensor Longus Digitorum: This so-called muscle arises from the distal portion of the median surface and the anterior border of the fibula. The tendon becomes free beneath the annular ligament, and is inserted on the proximal end of the fourth metatarsal bone, a slip being received on the fifth.

Variations.—The slip to the first toe is often distinct from the rest of the muscle. A slip may pass to the fifth toe. Some of the slips may be absent.

The Muscles of the External (Fibular) Region of the Leg and Foot.

The muscles of the external (fibular) region of the leg and foot include—

The Peroneus Longus.
The Peroneus Brevis.

THE PERONEUS LONGUS.

The Peroneus Longus muscle arises from the lateral and anterior surfaces of the head of the fibula, from the upper third to one-half of the fibula, by extensive oblique fibres from the septum between the muscle and the Extensor Longus Digitorum, and by relatively unimportant fibres from the head of the tibia and the Soleus and Flexor Longus Pollicis muscles.[1] From this extensive origin the muscle passes downward along the lateral border of the leg; the tendon becomes free at about the lower third of the fibula, and is directed behind the external malleolus, about which in company with the tendon of the Peroneus Brevis it turns to gain the outer side of the calcaneum, and the lateral border of the cuboid bone. It is thence deflected abruptly around the sole of the foot in a groove on the under surface of the cuboid bone to be inserted on the base of the first metatarsal bone.

Use.—To extend and abduct the foot and to turn the plantar surface somewhat outward, thus depressing the inner border of the foot. Acting with the Gastrocnemius and the Soleus it directly extends the foot. It is antagonized by the Tibialis Anticus, and in part by the Gastrocnemius and the Soleus.

C. Hueter[2] has made an elaborate study of the function of the Peroneus Longus and of other muscles supplied by the peroneal nerve. The actions, as observed by him, were modified by traumatic paralysis of the anterior tibial nerve.

Nerve.—The muscle is supplied by the musculocutaneous branch of the popliteal nerve.

The muscle is stout at its origin from the head of the fibula, but is thin and sheet-like as it arises from the shaft of the fibula.—While passing along the groove of the cuboid bone the tendon is secured from dislocation by a layer of the calcaneo-cuboid fascia or ligament. Nevertheless, such a dislocation is possible according to Bryant,[1] who quotes an instance.—At the ankle the tendon is held to the lateral side by an exceptionally broad and stout *vinculum* carrying bloodvessels. The tendon of the Peroneus Brevis is connected to that of the Peroneus Longus by a similar sheet.

Variations.—The Peroneus Longus may send slips to the fifth, first, or third metatarsal bone; to the first cuneiform, or to the cuboid bone, or to the external malleolus. It may fuse with the Peroneus Brevis. It may receive a slip at the origin from the Biceps Flexor.—A small slip of insertion may be continuous with the First Dorsal Interosseous muscle, and afford a small surface of origin for the Flexor Minimi Digiti.—At the main points of friction of the tendon, namely, at the external malleolus and at the groove of the cuboid bone, a sesamoid cartilage is not infrequently developed.—The lower of these nodules may undergo ossification.

Relations.—To the inner side lies the Extensor Longus Digitorum, to the outer side are the Soleus and the Flexor Longus Pollicis. The Peroneus Longus overlies the fibula and the Peroneus Brevis. At the ankle it lies in the same sheath with the Peroneus Brevis. In the foot it lies beneath the Abductor Minimi Digiti and the Adductor Pollicis.

Contracture of the Peroneus Longus depresses the internal border of the foot, and creases the integument of the sole, while the foot itself is abducted and rests upon the inner side. The internal malleolus is under these conditions unduly prominent. An instance described by Duchenne followed chorea, and was cured by faradization of the antagonistic muscles.

When the Gastrocnemius and the Soleus are atrophied, the Peroneus Longus, acting with the Extensor Communis Digitorum, can extend the foot at a right angle to the leg.

Atrophy of the muscle is followed by inclination inward of the plantar surface. In attempting to bring the sole of the foot to the ground, the great toe is involuntarily flexed. Thus a corn is developed upon the under surface of this toe. Flat foot follows in time.

In *talipes varus* the tendon of the Peroneus Longus runs below the calcaneum in a special groove, and does not lie upon the cuboid bone, which is without a groove.

THE PERONEUS BREVIS.

The Peroneus Brevis muscle arises from the lower half or two-thirds of the outer surface of the fibula by close-set muscular fibres, from the intermuscular

[1] The fibres of origin arrange themselves into two sets or imperfect laminations. The superficial or upper lamina arises from the head of the fibula and the head of the tibia, and is in part continuous with the Biceps Flexor. The deep or lower lamina arises from the remaining parts as described in the text. In the space between the laminæ the external peroneal nerve enters.

[2] Langenbeck's Archiv für Chirurgie, vol. vii. 1866, 827, fig.

[1] Surgery, 900.

septum between the Extensor Communis Digitorum and the Peroneus Tertius on the median side, and by a few unimportant fascicles from the Flexor Longus Pollicis on the lateral. The muscle passes downward, and becomes entirely tendinous at the level of the external malleolus, although the broad stout tendon extends partially concealed higher up the leg; it passes behind the external malleolus in company with the Peroneus Longus muscle to gain the outer side of the calcaneum, on the lateral surface of which it lies in a shallow oblique groove above a corresponding groove for the Peroneus Longus muscle, and is inserted upon the lateral process of the fifth metatarsal bone. A tendinous slip passes from the tendon of insertion to the base of the first phalanx of the fifth toe. Others ordinarily join the rudimentary fascia on the dorsum of the foot, or unite with the tendons of the extensors of the toes.

The sheaths and the vincula at the outer side of the ankle are so stout that they naturally assist the tendons of the Peroneus Longus and Peroneus Brevis in supporting the external lateral ligament.

Use.—To abduct the foot. Acting together with the Peroneus Longus, it aids in pronation, and together with the Tibialis Anticus in extension.

Nerve.—The muscle is supplied by the musculocutaneous branch of the popliteal nerve.

Variations.—Slips may join the Peroneus Longus and the Abductor Minimi Digiti. The tendinous slip to the fifth toe may be absent, or be compensatory with a slip from the Peroneus Tertius.

The Muscles of the Posterior Region of the Leg and Foot.

The muscles of the posterior region of the leg and foot include—

- The Gastrocnemius.
- The Soleus.
- The Plantaris.
- The Popliteus.
- The Flexor Longus Digitorum Pedis.
- The Flexor Accessorius.
- The Lumbricales.
- The Flexor Longus Pollicis Pedis.
- The Tibialis Posticus.

THE GASTROCNEMIUS AND SOLEUS.

The Gastrocnemius muscle arises tendinously by two heads from the femur, the larger inner head from above the inner condyle, and the outer head from above the lateral aspect of the outer. The two heads unite at the upper third of the leg, and are inserted by a broad aponeurosis upon the Soleus.[1]

The Soleus muscle arises from the posterior surface of the head of the fibula, from about the upper half of the outer border of the fibula, from the oblique line of the tibia, and from an arch of fibres which extend from the tibia to the head of the fibula. The muscle descends to form a massive tendon (tendo Achillis) about one and a half or two inches in length, which is inserted into the lower part of the tuberosity of the calcaneum.

Use.—The Gastrocnemius and the Soleus extend the foot at the same time that they produce a pivot movement in the ankle, to which is due the fact that the toes are carried inward and the heel outward; the outer border is at the same time depressed, and the foot is turned inward. The Gastrocnemius feebly flexes the leg on the thigh. When the leg is flexed on the thigh the muscle can extend the foot. The muscle acts in harmony with the Soleus, and in atrophy of this muscle is ineffective. When both muscles are atrophied the heel is depressed and the Peroneus Longus over-active. The action of the Gastrocnemius through its origin is to relax the capsule of the knee-joint.

Nerve.—The Gastrocnemius is supplied by a number of short nerves from the popliteal. The Soleus is supplied at the popliteal space by a single long nerve from the same trunk, which, as it descends, overlies the Plantaris muscle, and by a second smaller nerve which arises from the posterior tibial nerve in the calf of the leg.

Variations.—A sesamoid bone may be found in each of the two heads of the Gastrocnemius, but more commonly in the outer.[2] It may undergo incomplete longitudinal or complete planal cleavage. It may receive an accessory slip from the Biceps, and a few slips from the capsule, and have a third head from the femur or the capsule of the knee-joint.

Variations in the Soleus embrace planal cleavage in the origin from the head of the fibula. It may not fuse with the Gastrocnemius, and, in such an instance, may be inserted, separately therefrom, into the tuberosity of the calcaneum.—A few slips, arising from the deep tibial fascia, may be inserted into the inner side of the tendo Achillis, or pass to the annular ligament.—The origin from the oblique line is unimportant; this line is chiefly occupied by the Flexor Longus Digitorum and the Popliteus.

[1] This union is not bi-penniform, for no central tendon exists. It is composed of the expanded aponeurosis of the outer head which receives upon its superficies the fibres of the inner head.

[2] For an elaborate study of these bones see W. Gruber, Mém. de l'Acad. Imp. des Sciences. St. Petersbourg, 1876.

The outer head of the Gastrocnemius arises chiefly from the corresponding femoral condyle and from a small portion of the long external lateral ligament; the inner head arises directly behind the inner condyle, and is intimately associated with the capsule, entertaining in this respect the relation held by the Plantaris to the capsule over the outer condyle.—The inner head is obscurely bilaminate, the laminæ being in great part fused. The deep layer is directly continuous with the aponeurotic extension of the under portion at its insertion, while the superficial layer is directly continuous with its proximal border. The nerves and vessels enter between the laminæ. The outer head is not bilaminate.—From the fact that the outer head is the most constant, and is the sole head present, as a rule, in the lower animals, it may be regarded in the light of the main or ancestral head, to which the inner head has been subsequently added.

The Soleus is composed of three groups of muscular fibres. The median portion of the muscle is occupied by the first of these groups, and is composed of oblique fibres arising from the tibia. The lateral portion constitutes the second group, and arises from the fibula, while a third and smaller group lies between the two. The fibres of the groups are arranged obliquely to the longitudinal axis of the muscle, and those belonging to the first and the second are separated on the posterior surface of the muscle by the edge of a portion of a concealed tendon.

Relations.—The inner head, at its origin, overlies the stout tendon of the Semimembranosus. At and below the head of the tibia the inner head is loosely held throughout its entire extent to the tibia by the deep fascia and the tendons of the Gracilis and Semitendinosus muscles.

The Gastrocnemius overlies the Soleus, Plantaris, and Popliteus muscles, and in part the capsule of the knee, the popliteal vessels, and the internal popliteal nerve. The two heads form the inferior boundaries of the popliteal space. The popliteal nerve lies close to the inner side of the outer head.—To the outer side of the outer head lies the Biceps Flexor; to the median side of the inner head lie the hamstring tendons.—The Soleus lies over the posterior tibial fascia, and a space, crossed by a few bloodvessels and occupied by loose connective tissue, separates this fascia from the fibrous posterior surface of the Soleus.

The tendo Achillis is separated from the calcaneum by a bursa, and from the sheaths of the remaining tendons by a quantity of connective tissue.

In Talipes Equinus the tendon inclines toward the fibula.

The tendon is held in position by a girdle-like formation of deep fascia, and, as long as it is thus held, tends to be slightly curved.—In separation of the distal epiphysis of the tibia the slight curve in the tendon is exaggerated.[1] To the inner side of the tendon lie the posterior tibial vessels and nerve.

[1] R. Quain, Brit. Med. Journ., Aug. 31, 1867.

THE PLANTARIS.

The Plantaris muscle arises from the posterior surface of the outer condyle of the femur, and from the capsule of the knee-joint in the same neighborhood. It forms a slender belly that soon ends in a delicate narrow tendon which is inserted into the calcaneum at the median side of the tendo Achillis.

Use.—To aid the action of the Gastrocnemius.

Nerve.—The nerve of the Plantaris is derived from the internal popliteal.

Remarks.—This muscle has been known to be spontaneously ruptured, producing a peculiar dragging of the foot with eversion.

Relations.—The muscle at its origin lies to the median side of the outer head of the Gastrocnemius, and beneath the Soleus and the Gastrocnemius. It crosses the Popliteus muscle to gain its inner side, and along the corresponding side of the tendon of this muscle it descends to its insertion.

Variations.—The Plantaris is sometimes absent. Its belly may be inseparable from the outer head of the Gastrocnemius. Its tendon may be blended with the tendo Achillis, or be lost between the Gastrocnemius and the Soleus. Its origin may shift slightly downward, but retain its propinquity to the knee-joint. It may be inserted into the annular ligament, or into the fascia of the leg above it, or into the plantar fascia. It may have a supernumerary slip attached to the capsule of the joint.

THE POPLITEUS.

The Popliteus muscle arises by a stout tendinous origin from the upper and fore part of the popliteal groove on the external condyle of the femur. It passes downward and inward, receiving as it does so small fibrous slips from the external semilunar cartilage of the knee-joint, as well as one from the Semimembranosus muscle, and is inserted on the posterior surface of the shaft of the tibia as far as the oblique line, and along the median border of the shaft for the distance of two inches.

Use.—To aid in extending the leg and in fixing the position of the external semilunar cartilage.

Nerve.—The muscle is supplied by a branch of the internal popliteal nerve.

The tendon of the Popliteus passes within the knee-joint, and is enveloped by synovial membrane. Beneath the tendon lies a bursa which, as a rule, communicates with the joint. The belly is strengthened by an aponeurosis received from the Semimembranosus.—Some of the muscular fibres (arcuate fibres) are inserted into the posterior capsule of the knee-joint.—The popliteal groove is lined with cartilage, and is continuous with the synovial membrane, thus forming a part

of the articulation of the knee. As long as the limb is extended, the tendon of the Popliteus is not in the groove; but as the knee bends, the tendon slides over the smooth lip of the groove, and should the flexion continue to a considerable degree, the tendon at last slips into the groove, which may thus be said to have been formed for the occasional reception of the tendon of the Popliteus (Winslow).[1]

Variations.—The muscle may have a second head.[2] A sesamoid bone has been found in the tendon. The Semimembranosus may send slips of insertion to the fascia over the muscle.

THE FLEXOR LONGUS DIGITORUM.

The Flexor Longus Digitorum muscle arises from the oblique line and the posterior surface of the tibia from its middle third to within a short distance of the ankle, as well as from a fibrous septum between it and the Tibialis Posticus muscle. At the distal third of the leg the muscle forms a tendon which reaches to the inner side of the ankle, where it lies on the astragalus and the calcaneum, and, passing to the sole of the foot, divides into four tendons, which are inserted into the terminal phalanges of the four outer toes, piercing for this purpose the tendons of the Flexor Brevis Digitorum.

Use.—To flex the four outer toes.

Nerve.—It is supplied by a branch of the posterior tibial nerve.

The tendon lies in a distinct sheath, and is protected at the ankle by the stout annular ligament. Hyrtl describes this muscle as two-headed; the *long* head being that given above as the one for the entire muscle; the *short* head being the Flexor Accessorius.

Relations.—In the leg the muscle lies on the same plane as that of the Tibialis Posticus and the Flexor Longus Pollicis, and, like them, is covered to near the ankle by a layer of the deep fascia. At the ankle the tendon is in close association with the tendon of the Tibialis Posticus, but while it slightly overlies this tendon to the inner side, it is in a distinct sheath. In the sole of the foot the tendon passes beneath the Abductor Pollicis and the Flexor Brevis Digitorum, and lies at the median edge of the Flexor Accessorius in company with the tendon of the Flexor Longus Pollicis.

Variations.—It may undergo longitudinal cleavage. A second head may arise from the fibula.—It may fuse in part with the Tibialis Posticus or the Flexor Longus Pollicis.

The muscle is slightly separated from the tendon of the Tibialis Posticus in *talipes varus*, and a little below the level of the ankle-joint passes suddenly inward and backward at a right angle to the leg toward the sole of the foot.

[1] See also Knox's edition of Cloquet, and J. Goodsir's Anatomical Works.

[2] Gruber, Müller's Archiv, 1875, 599, fig.

THE FLEXOR ACCESSORIUS

The Flexor Accessorius is a square muscle arising from the calcaneum by two separate masses—one fleshy and broad, from the median surface of the bone, and one tendinous, from the lateral surface at a point in advance of the external tubercle. It is inserted into the oblique tendon of the Flexor Longus Digitorum.

Use.—To assist the Flexor Longus Digitorum.

Nerve.—It is supplied by the external plantar nerve.

Variations.—The muscle may secure an increased origin from the calcaneum, or a slip of origin from the leg—either from the fibula, the fascia, or from the Soleus or Peroneus Brevis muscles. It varies greatly in its insertion, tending in the main to send slips to the flexor tendons of the third and fifth toes.

THE LUMBRICALES.

The Lumbricales are slender fusiform muscles, four in number, arising from the median side of the tendons of the Flexor Longus Digitorum. They pass forward to the web of the foot, where they turn toward the dorsal surface, and are inserted on the dorsal aponeurosis (or tendon of the Extensor Longus Digitorum) at the distal end of the second phalanx of each of the four outer toes.

Use.—To assist the Extensor Longus Digitorum.

Nerve.—They are supplied by branches of the external plantar nerve.

Variations.—One or more of the muscles may be absent.

THE FLEXOR LONGUS POLLICIS.

The Flexor Longus Pollicis, the strongest muscle of the deep layer, arises from the distal two-thirds of the posterior surface of the fibula (excepting a small portion near the ankle), from the septum between it and the Peroneus Longus and the Peroneus Brevis, and from the posterior surface of the Tibialis Posticus muscle. The stout tendon becomes free near the ankle-joint, and descends to the sole of the foot close to the ankle joint, and lies deep within the interval between the internal malleolus and the astragalus, the posterior border of which it grooves, and is held close to the side of the calcaneum beneath the *sustentaculum tali*. The tendon in the sole of the foot passes along the median border, and is inserted into the terminal phalanx of the great toe. It constantly sends a slip to one of the tendons of the Flexor Communis Digitorum.

Use.—To flex the great toe. The tendon supports the ankle-joint posteriorly. It suffers contracture in atrophy of the Peroneus Longus.

Nerve.—It is supplied by a branch of the posterior tibial nerve.

The tendon of insertion can be traced within the muscle throughout its entire length as a broad coarse aponeurosis. At the region of the ankle-joint it lies in a distinct sheath.

Relations.—In the leg the muscle lies beneath the narrowing portion of the Soleus and the tendo Achillis. It lies upon the fibula and the Tibialis Posticus muscle. To the median side is the Flexor Communis Digitorum, and to the lateral the septum between it and the Peronei.

In the interval between the inner malleolus and the calcaneum, the tendons of the Tibialis Posticus, of the Flexor Communis Digitorum, and of the Flexor Longus Pollicis lie in close relation. The tendon of the Tibialis Posticus lies directly behind the inner malleolus; that of the Flexor Longus Pollicis (more deeply marked) near the astragalus, which it grooves at the posterior border; and that of the Flexor Communis Digitorum lies superficially between these two. The Flexor Longus Pollicis crosses the tendon of the Flexor Communis Digitorum at an acute angle to the median side of and beneath the Flexor Accessorius and Flexor Brevis Digitorum, and at its insertion lies between the sesamoid bones at the first metatarso-phalangeal joint.

In *talipes varus* the tendon does not run through the groove on the back part of the astragalus, and thence under the *sustentaculum tali*, but goes direct to the sole of the foot.

Variations.—The muscle, at its origin, is subject to few variations. It may be regarded as a derivative from the Flexor Longus Digitorum; from which, indeed, it is rarely entirely separated. As mentioned above, it is associated in its insertion with the same muscle, by sending a slip to the second toe in common with it. At times this slip is extended to one or more of the remaining toes. An attempt at longitudinal cleavage is rarely noted, the tendon being inserted, undivided, into the calcaneum. The tendon may send a fibrous slip to the Flexor Accessorius.

THE TIBIALIS POSTICUS.

The Tibialis Posticus muscle arises from that portion of the posterior surface of the fibula, from the tibio-fibular articulation to the middle of that bone, extending from the tibia at the margin of the interosseous membrane, from the entire posterior surface of the membrane itself, and from the septa between it and the other muscles of its group. The muscle forms a broad stout tendon at about the lower fifth of the leg, which lies at first in a groove on the tibia above the inner malleolus, then winds round the malleolus, and is inserted into the tuberosity of the scaphoid bone.

Use.—To extend the foot and to slightly adduct it. It is the chief factor in drawing the scaphoid bone inward and upward in *talipes varus*, and is assisted by the Tibialis Anticus and the Extensor Proprius Pollicis. The tendon supports the internal lateral ligament and the inferior calcaneo-scaphoid ligaments. It is active in the act of climbing.

Nerves.—It is supplied by a branch of the posterior tibial nerve.

The muscle is obscurely bipenniform in appearance, the concealed tendon passing nearly the entire length of the muscle. The tendon sends a stout fibrous slip backward to the calcaneum at the sustentaculum tali.

Relations.—At the proximal portion the muscle is beneath the lower border of the Popliteus. In the calf it lies beneath the Soleus. Between the tibial and fibular origins the posterior tibial artery and nerve pass down the leg. Anteriorly the muscle lies on the interosseous membrane. To the inner side is the Flexor Longus Digitorum, and to the outer the Flexor Longus Pollicis.

The tendon, at the ankle, lies nearest to the bone, and comes well up in relief in adduction of the foot. It lies close to and parallel with the inner edge of the tibia, so that this edge is the best guide to it. Therefore in tenotomy the knife is introduced perpendicularly between the tendon and the bone.

Variations.—It may be in part fused with the Flexor Longus Digitorum. It may send slips of insertion into the bases of all the toes. The occasional slip to the internal cuneiform bone may be blended with the Flexor Brevis Pollicis. A nodule of fibro-cartilage found in the tendon at the internal malleolus sometimes becomes ossified. A tendinous slip may be tributary to the tendon of the Peroneus Longus. The muscle may be absent.—A nodule of fibro-cartilages (sometimes bony) is often found in the tendon as it winds round the malleolus.

Remarks.—In *talipes varus* the tendon of the Tibialis Posticus pursues a nearly straight course downward, and near its insertion is slightly inclined backward, and is thus less closely held to the inner malleolus than is the case in the normally constructed foot.—The muscle is pushed backward or is torn in lateral dislocation of the astragalus.[1]

In a case recorded by Mr. Stanley,[2] the bursa underlying the tendo Achillis became the seat of inflammatory thickening and distension. The skin sloughed, and an ulcer developed which extended down into the sole of the foot and exposed the common sheath of the Tibialis Posticus and the Flexor Longus Digitorum.

[1] Paul Broca, Mém. Soc. Chir., iii. Paris, 1853.

[2] Med. Times and Gazette, July 13, 1880.

The Muscles of the Sole of the Foot.

The muscles of the sole of the foot are divided, for convenience in dissecting, into four layers.

The muscles of the first layer include—

The Flexor Brevis Digitorum.
The Abductor Pollicis Pedis.
The Abductor Minimi Digiti.

THE FLEXOR BREVIS DIGITORUM.

This muscle arises from the inner tuberosity of the calcaneum, from the plantar fascia near this origin, and from the intermuscular septa on either side. It passes forward and divides beneath the metatarsus into four small rounded tendons, which are pierced by the tendons of the Flexor Longus Digitorum, and are inserted into the second phalanges of the four outer toes.

Use.—To flex the toes.

Nerve.—The muscle is supplied by branches of the internal plantar nerve.

Variations.—But three tendons may be present, the fifth toe being without connection with the muscle. The muscle may secure a slip from the tibia. It may arise from both calcaneal tuberosities and from the space between them.

THE ABDUCTOR POLLICIS PEDIS.

The Abductor Pollicis Pedis muscle arises from the tubercle on the median surface of the calcaneum, from the annular ligament, and from a tendinous arch overlying the plantar vessels and nerves. It passes forward along the inner border of the foot, the tendon becoming free at the metatarso-phalangeal joint, and is inserted on the first phalanx of the first toe and on the inner sesamoid bone.

Use.—To abduct the first toe.

Nerve.—The muscle is supplied by a branch of the internal plantar nerve.

Variations.—It may send a slip to the first phalanx of the second toe, or to the skin of the ball of the first toe.

ABDUCTOR MINIMI DIGITI.

This muscle arises from the under surface of the calcaneum at and between the tuberosities, and from the plantar fascia and the external intermuscular septum. It passes forward along the lateral margin of the foot, and is inserted into the lateral surface of the proximal end of the first phalanx of the fifth toe.

Use.—To abduct the fifth toe. It acts as a cushion to the median border of the sole.

Nerve.—The muscle is supplied by the external plantar nerve.

Variations.—The muscle is often described as connected with a slip of the plantar fascia extending from the calcaneum to the fifth metatarsal bone. A variable slip is often inserted into the fifth metatarsal bone. It may fuse with the Flexor Brevis Pollicis and the Adductor Pollicis. The Abductor Pollicis and Adductor Pollicis with the Flexor Brevis Pollicis may be regarded as homologous with the parts of a metatarso-phalangeal flexor of the mammalian foot.

The muscles of the second layer include—

The Flexor Accessorius.
The Lumbricales.

For accounts of these muscles see page 317.

The muscles of the third layer include—

The Flexor Brevis Pollicis Pedis.
The Adductor Pollicis.
The Transversalis Pedis.
The Flexor Minimi Digiti.

THE FLEXOR BREVIS POLLICIS PEDIS.

This muscle arises by two obscurely defined heads: one from the plantar surface of the first cuneiform bone, from the calcaneum, from the sheath of the Flexor Longus Digitorum, and from the adjacent fibrous tissue; and the other from the cuboid and third cuneiform bones. The fascicle of the inner head passes forward parallel with the tendon of the Abductor Pollicis, and is inserted into the inner sesamoid bone at the first metatarso-phalangeal joint. The fascicles of the outer head are inserted into the outer sesamoid bone in company with the tendon of the Transversalis.

Use.—To flex the first toe.

Nerve.—The muscle is supplied by the internal plantar nerve.

Variations.—The inner head often receives a slip from the Tibialis Posticus. It may fuse in part with the Abductor Pollicis and the Adductor Pollicis.

The Flexor Brevis Pollicis is a survivor of a group of metatarso-phalangeal flexors almost constantly present in the mammalian foot.

THE ADDUCTOR POLLICIS

muscle arises from the plantar aspect of the cuboid and of the third cuneiform bones, from the proximal ends of the third and fourth metatarsal bones, and from the sheath of the Peroneus Longus muscle. It passes forward and inward, and is inserted on the outer sesamoid bone at the first metatarso-phalangeal joint.

Use.—To adduct and flex the first toe.

Nerve.—The muscle is supplied by the deep branch of the external plantar.

Variations.—It may send a slip to the base of the first phalanx of the second toe. It may fuse in part with the outer head of the Flexor Brevis Digitorum and the Flexor Brevis Pollicis.—Under the head of Opponens Hallucis some anatomical writers include a frequent variation of the Adductor. It is inserted into the metatarsal bone of the first toe.

THE TRANSVERSALIS PEDIS.

This muscle is closely allied to the foregoing. It arises by separate slips from the capsules of the metatarso-phalangeal joints and the associated fibrous tissues. It passes toward the median border of the foot, and is inserted into the fascia on the outer side of the lateral sesamoid bone over the Adductor Pollicis. It lies directly beneath the tendons of the Lumbricales.

Use.—To assist in adducting the first toe.

Nerve.—The muscle is supplied by the deep branch of the external plantar.

THE FLEXOR MINIMI DIGITI.

This muscle arises from the sheath of the Peroneus Longus and the base of the fifth metatarsal bone, and is inserted into the under surface of the metatarso-phalangeal joint of the fifth toe.

Use.—To indirectly flex the fifth toe by making traction on the plantar portion of the capsule of the fifth metatarso-phalangeal joint.

Nerve.—The muscle receives a branch from the superficial branch of the external plantar nerve.

Variations.—It may send a slip to the base of the first phalanx of the fifth toe, or to the lateral aspect of the joint. The muscle is a rudiment of the fifth Metatarso-Phalangeal Flexor of quadrupeds.

The muscles of the fourth layer include—
The Interossei.

THE INTEROSSEI.

These muscles are composed of the dorsal and the plantar set. Each consists of a single belly and a distinct tendon, which is inserted into the dorsal aponeurosis of the phalanges at the metatarso-phalangeal joint.

The Dorsal Interossei, four in number, are arranged as follows: Each muscle, excepting the first, arises from the opposed sides of the interosseous space, within which it is lodged, and on a level with the dorsum of the foot.

The *first* arises from the borders of the first interosseous space, and is inserted into the extensor tendon and the base of the first phalanx.

The *second* arises from the second interosseous space, and is inserted into the first phalanx of the second toe on its lateral surface.

The *third* arises from the third interosseous space, and is inserted into the first phalanx of the third toe on its outer border.

The *fourth* arises from the fourth interosseous space, and is inserted into the first phalanx of the fourth toe on its outer border.

Use.—The outer three muscles are abductors of the second, third, and fourth toes respectively, while the first is an adductor of the second toe, and assists the Plantar Interossei.

The Plantar Interossei, three in number, are small muscles, each a single, slender, fusiform mass, lying on a level with the plantar surface of the foot, and lodged in the interosseous spaces, but not, as in the case of the dorsal muscles, entirely occupying them.

The muscles are arranged as follows: They are placed on the median side of the lower surface of the third, fourth, and fifth metacarpal bones, respectively, and are inserted into the dorsal aponeurosis of the corresponding metacarpo-phalangeal articulation at the median margin.

Use.—To flex the first phalanx and extend the second and third phalanges. In addition they adduct the toes upon which they are inserted.

Nerves.—The nerves of both groups of Interossei are supplied by the deep branch of the external plantar.

Geo. Ruge,[1] who has studied the development of the intrinsic muscles of the foot, has arrived at the conclusion that the muscles were all originally plantar, and that the Dorsal Interossei are the results of advanced specialization by which plantar slips are pushed through the intermetatarsal spaces, and ap-

[1] Morph. Jahresbr. iv. 1878, 117, supplement.

EXPLANATION OF PLATE LVI.

Fig. 1. The plantar fascia.

Fig. 2. The superficial muscles (first layer) of the sole of the foot.

Fig. 3. The second layer of muscles of the sole of the foot.

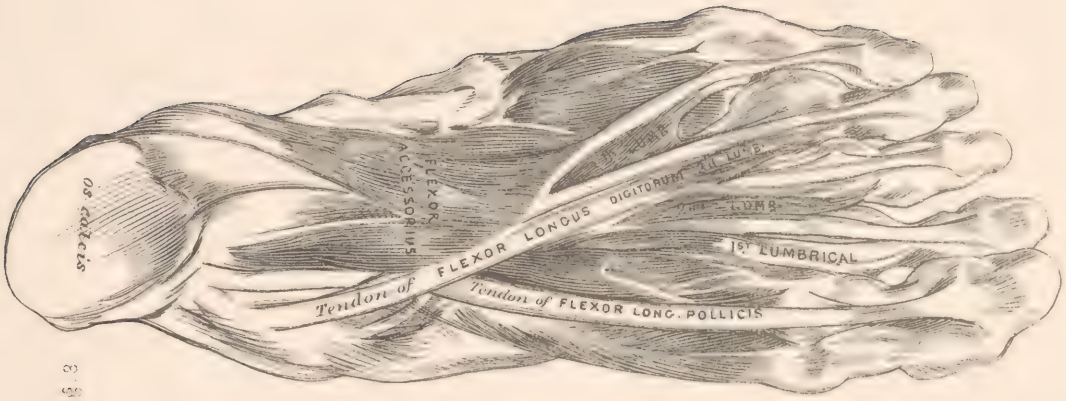


Fig 3

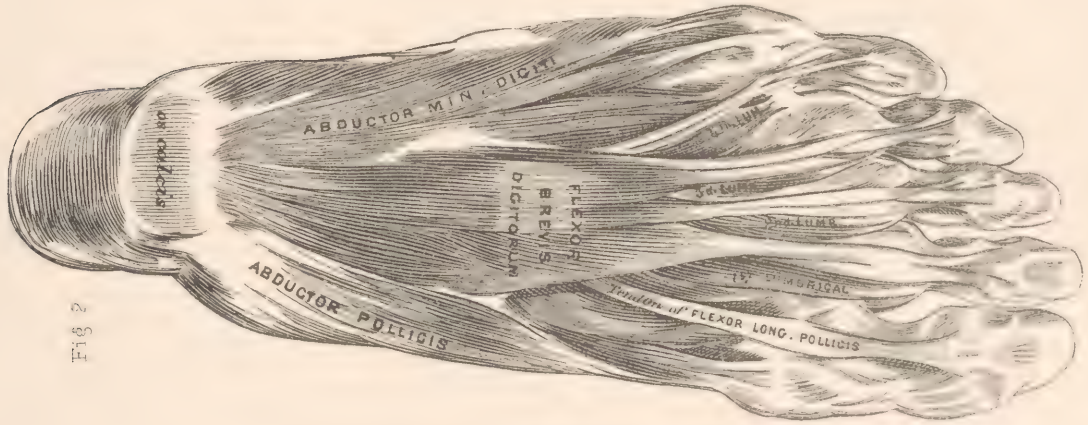


Fig 2



Fig 1

T. Sinclair & Son, Lith.

pear in time on the dorsal surface of the metatarsus. The dorsal muscles are thus seen to be of less importance than the flexors, and may be absent or imperfectly differentiated.

D. L. Cunningham[1] divides the interosseous muscles of the foot into the plantars or adductors, the dorsals or abductors, and the intermediate group or the flexors.

The Deep Fasciæ of the Lower Extremity.

The Deep Fascia of the Thigh.—The plan of arrangement of the fascia of the thigh is best understood by bearing in mind the important relations existing between the trunk and the lower extremity. These are quite different from those existing between the trunk and the upper extremity. In the former the aponeurosis of the muscular abdominal wall and the sub-peritoneal connective tissue are continuous with the fasciæ of the limb. In the latter the aponeurotic extension from the chest-wall does not involve any important muscular action, nor is it anywhere of special strength; and the thoracic region in no way contributes to the formation of the brachial fascia.

The fasciæ of the thigh are derived from three sources: (1) the back; (2) the anterior wall of the abdomen; and (3) the interior of the abdomen.

(1) *The Fascia Derived from the Back.*—The Gluteus Maximus muscle is covered by a thick layer of firm adipose tissue, and the muscle itself is intimately incorporated with a fibrous sheath. The Gluteus Medius muscle is covered by a well-defined layer of fascia, which is in common with that of the Tensor Vaginæ Femoris. The lower portion of the Gluteus Maximus yields an important accession to this system of fasciæ, and contributes to form the thick and important aponeurosis of the outer side of the thigh, which has received the name of the fascia lata. Posteriorly the *fascia lata* is attached to the outer lip of the linea aspera, and to the intermuscular septa of the posterior femoral group of muscles. The Vastus Externus receives accessions from it in front, and the short head of the Biceps Flexor behind. Inferiorly the fascia forms a rounded cord lying directly beneath the skin above the outer femoral condyle. Some writers trace the fascia lata to the head of the fibula; and consider such fibres as can be traced in a straight line to the Tensor Vaginæ Femoris as functionally the tendinous fibres of insertion of that muscle. Whether the innovation be adopted or not, it is of value to insist upon the functional relation existing between the Tensor Vaginæ Femoris and other muscles of the same group which are inserted, in part, at least, upon the fascia lata. The fascia lata may be defined as that part of the femoral aponeurosis which can be influenced by the action of the muscles of the gluteal group.

Anteriorly the fascia lata divides at the posterior border of the Sartorius muscle, one layer passing in front, the other behind. Upon the inner (median) border of the muscle, the fascia, although often denominated the fascia lata, will in this connection be designated as the *sartorial fascia.*

Pus or blood under the fascia lata develops a well-defined group of characters. As a result of spontaneous rupture of a femoral aneurism, the blood spreads rapidly in the cellular interspaces of the thigh, and causes the integument from the groin to the knee to swell uniformly and to present the superficial appearances of a deep abscess. Such a collection has at times been opened by incautious surgeons, with the unexpected result of fluid arterial blood escaping from the puncture instead of pus. Richet,[1] who dissected the thigh of a subject in which the condition described above had been detected during life (the external iliac artery having been secured), found that the blood had not only infiltrated the muscular interspaces and the cellular tissue, but even the muscular substance itself; yet, in spite of the enormous pressure which had been brought to bear to effect such a result, the fascial covering of the thigh remained intact.

Mr. John Adams[2] records an example of a femoral hernia descending beneath the fascia lata over the Pectineus muscle, behind the sheath of the femoral vessels, but to the inner side of the vein.

The muscles inserted on the fascia lata may slightly extend the leg after fracture of the patella.[3]

(2) *The Fascia Derived from the Anterior Wall of the Abdomen.*—The *sartorial fascia* is the same as the iliac portion of the fascia lata of authors. It is derived from the anterior wall of the abdomen, and is continuous with the aponeurosis of the External Oblique muscle at the front of the thigh. In passing to the groin, it forms Poupart's ligament, and below this structure it is continuous with the fascia lata at the Sartorius muscle.

This layer of fascia might be compared to an apron attached above at the aponeurosis of the External

[1] Traité Prat. d'Anat. 1869, 982.

[2] Med.-Chir. Trans. xliii 127.

[3] W. W. Keen, Annals of Anat. and Surg., Jan. 1881.

Oblique, and hanging downward over the groin. It differs from most of the deep fasciæ of the body in being intimately connected with the superficial fascia, and in being itself freely divisible. In a word, it is of a relatively loose texture, and readily permits of lamellar division by dissection, perforation by vessels, and the lodgment of fat and lymphatic glands. Inferiorly, it is gradually lost upon the Sartorius and Gracilis muscles, besides giving accessions to the femoral sheath and intermuscular septa, while to the inner (median) side it is continuous with a deeper layer of fascia known as the *pectineal* fascia.[1]

(3) *The fascia derived from the interior of the abdomen.*—The layer derived from the interior of the abdomen consists of the subperitoneal connective tissue. The transversalis fascia is derived from the parietal layer of the abdomen, and serves to strengthen the previous layer. It is for the most part inserted at the line of Poupart's ligament, although the anterior surface of the femoral vessels receives an important accession from its inner (median) portion. The last-mentioned membrane is sometimes called the *deep crural arch.*—The *pectineal fascia* is the same as the pubic portion of the fascia lata of authors. It is derived from the iliac fossa, and, passing out of the pelvis at the crural arch, forms the posterior wall of the femoral sheath, and is continuous, over the Pectineus muscle, with the fibrous sheaths of the muscles at the inner side of the thigh. Here it is lost in the general fibrous sheaths and septa at the lower part of the thigh, becoming continuous with the fascia lata posteriorly, and with the sartorial fascia anteriorly.

For details of this and the preceding portion see Surgical Anatomy of Femoral Hernia.

The Deep Fascia of the Leg.—The deep fascia of the leg forms a uniform covering for the muscles, and, indeed, for the entire leg excepting the subcutaneous inner (median) surface of the tibia.

The posterior portion of this fascia is divided into a superficial and a deep division: the former embraces the Gastrocnemius, the Soleus, and the Plantaris; the latter forms a well-defined transverse membrane which stretches across parallel to the plane of the tibia and fibula, and which covers in the posterior part of the Tibialis Posticus, the Flexor Longus Digitorum, and the Flexor Longus Pollicis, with the posterior tibial vessels and nerve.

The fascia of the inner aspect of the leg, in addition to affording sheaths to the several muscles, yields partial origin to the Tibialis Anticus and the Extensor Communis Digitorum. Pronounced septa extend between the peroneal and anterior tibial groups of muscles on the one hand, and between the peroneal and posterior tibial groups on the other.

The fascia of the leg is made tense by the muscles of the thigh. The Semimembranosus affects the posterior portion over the inner head of the Gastrocnemius; the Gracilis, the fascia over the belly of the Gastrocnemius; the Semitendinosus and the Sartorius, the fascia over the front of the leg; and the Biceps Flexor Femoris that over the fibula and adjacent parts.

The Plantar Fascia.—The plantar fascia is a thick layer of fibrous tissue occupying the sole of the foot between the skin and subcutaneous fat and the first layer of muscles. It is divided into three portions, the inner, middle, and outer.

The *inner portion* lies over the Abductor Pollicis muscle. Posteriorly it forms an arch extending from the inner malleolus to the calcaneum, behind which pass the plantar vessels.

The *middle* or *main portion* lies over the short flexor of the toes. At its origin from the under aspect of the calcaneum it is tense and of uniform thickness. As it passes forward it becomes weaker, and finally splits up into five slender divisions, one for each of the toes. It also sends fasciculi of support to the metatarso-phalangeal joints, and strengthens the fibres connecting them.

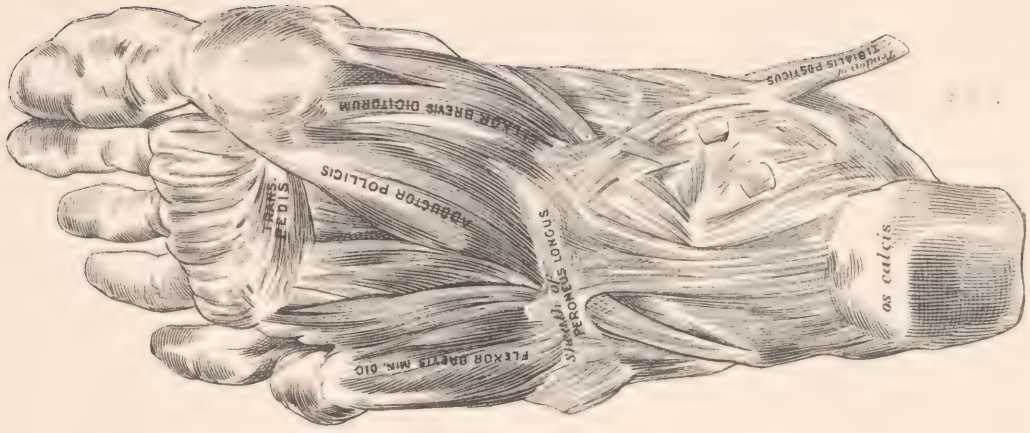
The *outer portion* is less uniform than the others. In addition to covering in the Abductor Minimi Digiti and the Flexor Minimi Digiti, and being inserted upon the distal end of the fifth metatarsal bone, it sends a stout slip from the calcaneum to the base of the fifth metatarsal bone.

The following is a list of the superficial bursæ of the inferior extremity: one over the trochanter major;

[1] For a special study of the fascia lata, see H. Welcker, Archiv für Anat. und Physiologie, 1876, fig.

EXPLANATION OF PLATE LVII.

Fig. 1. The third layer of muscles of the sole of the foot.
Fig. 2. The interossei muscles of the foot, seen from below.
Fig. 3. The interossei muscles of the foot, seen from above.







T. Sinclair & Son Lith.

one over the tuberosity of the ischium; a patellar bursa; three in the popliteal space, an internal, external, and median (in connection with which Coulson narrates an instance of a female, aged thirty-two, in whom a bursal tumor containing an ounce and a half of fluid formed in the middle of the popliteal space); one over each malleolus, that over the external being the larger; and one over the distal end of the first metatarsal bone.

The Anatomy of the Parts Involved in Inguinal and in Femoral Hernia.

(a) inguinal hernia.

Since much of the interest of the study of fascia pertains to hernia, the varieties of this lesion will be here discussed, and the structural features in connection therewith be given in the order of their importance. By *inguinal hernia* is meant a protrusion of some of the contents of the abdominal cavity along the path already selected in the male by the testis in its descent from the abdomen, or in the position of the round ligament in the female. Ordinarily a loop of the small intestine constitutes the hernia. The cæcum and a portion of the omentum may also be engaged. Other contents of a hernial protrusion are so rare that they need not here be mentioned. The anatomy of inguinal hernia will be described as occurring in the male.

In the descent of the testicle a part of the peritoneum is carried therewith to the bottom of the scrotum. In normal development the lower part of this extension of the peritoneum forms the *tunica vaginalis*, while the connection between it and the peritoneal cavity disappears. If it should not disappear, but remain open, opportunity is afforded for loops of intestine to descend as far as the testis. This constitutes *congenital inguinal hernia*. If the sac of such a hernia is improperly formed, and the peritoneal canal simply narrowed but not obliterated, the hernia occurring therein is called *infantile*. It is evident, however, that this condition is simply a variety of congenital hernia.

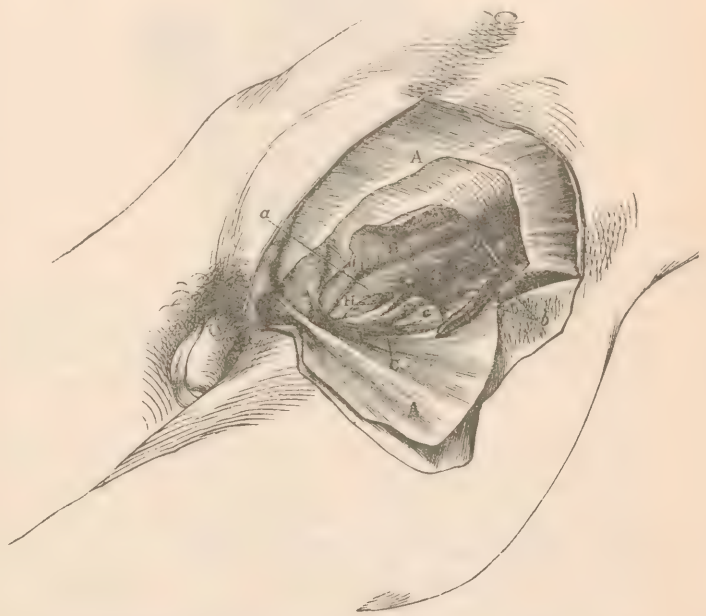
Hernia occurring under circumstances other than those mentioned above is called *acquired*.

The coverings of hernia will be described from within outward.

An examination of the inner surface of the anterior wall of the abdomen above the groin in a subject whose arteries have been injected will show two shallow depressions of the peritoneum immediately above Poupart's ligament. Between them extends a vertical or nearly vertical elevation which corresponds to the position of the deep epigastric artery. These depressions are intimately concerned in the mechanism of inguinal hernia. If the loop of intestine carries the *outer* (lateral) depression or pouch in front of it, it forms what is known as *indirect inguinal hernia;* if it carries the *inner* (median) depression in front of it, it forms *direct inguinal hernia.*

Indirect Inguinal Hernia.—A protrusion of intestine through the outer pouch pushes before it first the peritoneum lining the pouch. Beneath the peritoneum lies the sub-peritoneal connective tissue or transversalis fascia. The loop thus covered pushes its way through the internal abdominal ring into the inguinal canal, and, inasmuch as this ring is occupied by connective tissue known as the *infundibuliform fascia*, the hernia acquires a third layer. If the protrusion goes no further, the lesion constitutes *incomplete* inguinal hernia, and possesses as additional coverings—the tendon of the external oblique abdominal muscle, the superficial fascia, and the integument. Ordinarily, however, it descends the entire length of the inguinal canal in company with the spermatic cord, which lies to its inner (median) side, and escapes at the external abdominal ring, where it constitutes *complete* inguinal hernia, and loses the external abdominal muscle as a covering. An old neglected complete inguinal hernia is apt to gravitate into the scrotum, where it will add the scrotal tissues to its

Fig. 78.



View of the Parts Concerned in Inguinal Hernia.—A. External oblique tendon, thrown down. B. Internal oblique, the lower part raised. C. Cremaster muscle in its natural position D. Transversalis muscle with a free border. F. Spermatic cord. G. Fascia transversalis. H. Conjoined tendon. *a*. Epigastric vessels. *b*. Branch of the circumflex iliac artery.

coverings, including the Cremaster muscle which is composed of a few of the lower fibres of the Internal Oblique muscle which have been carried downward in the descent of the testicle.

Accordingly, in cutting down upon a complete indirect inguinal hernia, the following structures are met with in the order named:—

Skin, subcutaneous or superficial fascia, Cremaster muscle, infundibuliform fascia, transversalis fascia, and the peritoneum. The structure last named is called the sac of the hernia, and usually contains a moderate quantity of serous fluid.

When a hernia can be replaced at will in the abdomen it is said to be *reducible*, and when it cannot be replaced, *irreducible*. *Irreducible* or *incarcerated hernia* may in turn become strangulated, when, the bloodvessels of the loop of intestine being compressed, the integrity of the parts is seriously threatened.

The point of constriction of a strangulated inguinal hernia is ordinarily at the neck of the sac, that is, at the point where the sac is held at the internal abdominal ring.

Direct Inguinal Hernia.—Should the pressure against the abdominal walls cause the loop of intestine to protrude within the inner pouch or depression (known also as the triangle of Hasselbach), the lesion termed *direct inguinal hernia* is initiated. The loop in

Fig. 79.



View of the Parts Concerned in Femoral Hernia.—A. Iliacus covered by the iliac fascia. B. Rectus. C. Transversalis covered by the transversalis fascia. D. Crural ring. E. Gimbernat's ligament. *a*. Iliac artery. *b*. Iliac vein. *c*. Epigastric branch of external iliac. *d*. Circumflex iliac *e*. Obturator artery, with its nerve. *f*. Small branch joining the obturator and epigastric arteries.

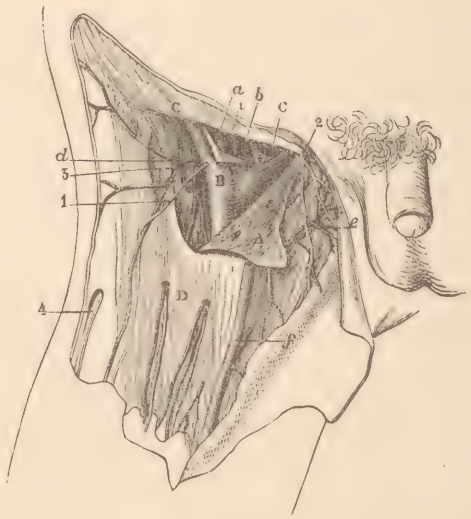
this variety carries before it the peritoneum and the transversalis fascia as in the indirect form. The hernia next pushes before it the conjoined tendon of the Internal Oblique and Transversalis muscles, and presents itself at the external abdominal ring, through which it protrudes. It now secures additional coverings of superficial fascia and skin, and lies above and to the outer side of the spermatic cord. Prof. D. H. Agnew doubts that this hernia ever retains the conjoined tendon as a covering. In his judgment the loop escapes to the outer side of the conjoined tendon.

Proceeding from without inward the coverings of a direct inguinal hernia are as follows: skin, superficial fascia, conjoined tendon (?), transversalis fascia, and peritoneum (sac). In both varieties of inguinal hernia it is important to remember the position of the deep epigastric artery. In the *indirect* the artery lies to the *inner* side of the neck of the sac; in the *direct* it lies to the *outer* side.

(b) FEMORAL HERNIA.

In this variety of hernia the loop of intestine escapes to the inner side of the track prepared for the accommodation of the femoral vessels. As in the previous examples, the loop of intestine pushes before it a layer of peritoneum and of subperitoneal connective tissue. The subperitoneal connective tissue just mentioned is often called the *septum crurale*, by reason of its position. The *femoral ring* lies to the inner (median) side of the femoral vein. It is defined above by Poupart's ligament below by the linea ilio-pectinea, to the outer

Fig. 80.



View of the Fascia and Associated Parts below Poupart's Ligament.—A. Fascia lata reflected. B. Crural sheath opened. C. Poupart's ligament. D. Fascia lata of the thigh in place. ‡ Two septa dividing the space of the crural sheath into three compartments. *a*. Femoral artery; *b*. Femoral vein; and *c*. A lymphatic gland, all in the crural sheath. *d*. Superficial circumflex iliac artery. *e*. Superficial pudic artery. *f*. Saphenous vein. 1. Genito-crural nerve. 2. Ilio-inguinal nerve. 3. External branch of middle cutaneous nerve. 4. External cutaneous nerve.

side by the femoral vein, and within by a downward expansion of Poupart's ligament known as Gimbernat's ligament. Before advancing further, a knowledge of the relations existing between the abdominal and femoral fasciæ is necessary.

The Crural Arch.—The lower border of the anterior parietes of the abdomen and the upper border of the

anterior femoral region are contiguous at the groin. A line drawn from the anterior superior spinous process of the ilium to the pubis represents the lower border of the abdominal muscles, and the upper border of the femoral fasciæ. By removing the abdominal muscles from about this line, and deflecting them upward, and by removing the femoral fasciæ therefrom and deflecting them downward, there can be felt in position a fibrous cord extending between the ilium and the pubis, which has received the name of *Poupart's ligament* or the *crural arch*. It is of great importance to remember that the cord or ligament has no existence in nature, but is a product of the dissector's art.

The space which intervenes between Poupart's ligament and the innominate bone is often spoken of as the *crural arch* as well as the ligament itself. In the same manner as one can use the terms *arch* and *archway* interchangeably, so one may speak of Poupart's ligament and the space beneath it. Strictly speaking, however, the ligament constitutes the *arch*, and the space beneath the *archway*.

In this sense the crural arch is secured to the pubis by a broad triangular abutment which has received the name of *Gimbernat's ligament*. This abutment differs from Poupart's ligament in receiving few or no fibres from the femoral fasciæ, but all or nearly all from the abdominal muscles. It strengthens the attachments of the External Oblique muscle, is nearly horizontal in the erect subject, and occupies the narrow acute interval between the pubic end of Poupart's ligament and the ilio-pectineal line.

The crural archway is occupied at its outer (lateral) half by the Iliacus Internus and the Psoas Magnus muscles. The external cutaneous nerves escape near the anterior superior spinous process, and the anterior crural nerve between the Iliac and the Psoas muscles. The inner (median) half is occupied by the femoral vessels, the artery lying to the outer side, and the vein to the inner. These structures are included in the *femoral sheath*, which is composed of three compartments—one for the artery, one for the vein, and one occupied by a small quantity of connective tissue (transversalis fascia, crural septum), and by an occasional lymphatic gland. It is along this last compartment that a femoral hernia descends. In technical language, it may be said to lie within the *femoral canal*, which extends from the *femoral ring* at the plane of Poupart's ligament and of Gimbernat's ligament to the *saphenous opening* in the deep femoral fascia. The manner of formation of the femoral canal is much more intricate than that of the inguinal canal, and requires for its comprehension an exact knowledge of the fasciæ of both the abdomen and the thigh.

The Fasciæ of the Thigh in connection with the Anatomy of Femoral Hernia.—It has been said that the femoral ring is bounded externally by the femoral vein. In more exact language, it is bounded by the sheath enclosing this vessel and the femoral artery. What composes this sheath? The external iliac vessels (artery and vein) do not possess a sheath. What are the structures thus seen abruptly investing these vessels at the point of their exit from the trunk, and why the assumption of new names for them? To answer these questions we are compelled to make a careful study of the sub-peritoneal connective tissue. Beneath the parietal (anterior) layer of the peritoneum lies a layer of connective tissue called the *transversalis fascia*. Beneath the visceral (posterior) layer, as applied over the Iliac and Psoas muscles, the connective tissue layer is called the *iliac fascia*. Now the transversalis fascia is lost upon Poupart's ligament throughout its entire length, except where the femoral vessels escape. At this point the transversalis fascia is continuous with and indeed forms the *anterior layer* of the femoral sheath. The *iliac fascia* in its turn, while continuous with Poupart's ligament at its outer (lateral) half, is free from and passes beneath this structure at its inner (median) half. It constitutes the deep layer of the femoral fascia (pectineal fascia) at the same time that it forms the *posterior layer* of the femoral sheath. The median and lateral limits of the sheath are of the nature of *septa*.

The superficial layer of the deep femoral fascia (often spoken of as the iliac portion of the *fascia lata* or the *sartorial fascia*) is continuous above with Poupart's ligament. It covers the femoral vessels and sheath in front, and is continuous with the *pectineal fascia* (pubic fascia, pubic portion of fascia lata) at the *inner* aspect of the thigh. This blending of the two layers, which will henceforth in this description be spoken of as the *sartorial* and the *pectineal fasciæ*, is interrupted at about the position of the femoral vein by an elliptical opening, measuring about an inch and a half in its longest diameter, designed to transmit the long saphenous vein from the plane of the sartorial fascia to the femoral sheath. This interruption constitutes the *saphenous opening*. It is imperfectly defined below, where the two layers of femoral fascia blend insensibly, but is sharply limited above on the plane of the sartorial fascia. This upper trenchant edge is crescentic, and its concavity is directed outward. In surgical language it is called the *falciform* process, or *Hey's ligament*.

Not only does this ligament define the upper and outer lateral borders of the saphenous opening, but it is continuous beneath the pubic attachment of Poupart's ligament with Gimbernat's ligament. The inner (median) border of the saphenous opening is thus on a lower plane than the upper and outer border. It is not sharply defined, but is represented by a smooth layer of pectineal fascia which is traceable upward *beneath* the femoral ring to the iliac fascia of the trunk.

The *femoral* or *crural canal* is thus seen to be a curved passage of intricate outline determined by the relation of the superficial and deep layers of femoral fascia, and by the different planes which these structures necessarily occupy at the region of the groin. The loop of intestine passing along this canal receives no additional covering. When, however, it reaches the saphenous opening, it encounters the general superficial fascia of the thigh, which has here received the distinctive name of the *cribriform fascia* from its sieve-like appearance. From the structural peculiarities of the saphenous opening already noticed, the loop of intestine inclines upward, and is turned abruptly over the sharp edge of Hey's ligament.

The *coverings of femoral hernia* from without inward are, therefore, skin, cribriform fascia, transversalis fascia (crural septum), and peritoneum. Sir Astley Cooper and his followers accept the so-called *fascia propria* as a layer in place of the crural septum. The fascia propria is by these writers said to intervene between the cribriform fascia and the crural septum, and to be derived from the sheath of the femoral vessels.

The *point of constriction* in femoral hernia is commonly at the femoral ring, where either Hey's ligament or Poupart's ligament requires nicking before the constriction is overcome. In attempts at the *reduction of a femoral hernia* it is of importance to remember the flexion of the hernial mass upward over Hey's ligament. The loop must be drawn downward from this position, and brought in the same line with that of the femoral canal before success can be expected. When the thigh is flexed and carried across its fellow, all the fascial expansions at the groin are relaxed. This, therefore, becomes the most favorable position in which the limb can be placed for the reduction of femoral hernia.

A knowledge of the relations of the obturator artery is of importance in the operation for femoral hernia.[1]

[1] For figures of the fascia of the lower extremity, the reader is referred to Plate LXXV.

VI. THE MUSCLES AND FASCIÆ OF THE PERINEUM.[1]

The perineum is the region which limits the trunk inferiorly, and is composed of those structures which fill in the inferior strait of the pelvis. Its boundaries are thus the same as those of the pelvic outlet, while its components of necessity vary in the two sexes.—In the *male* the perineum is composed of the anus, and the muscles inserted into it, of the bulb of the spongy body, and of the muscles connected therewith. The skin-surface of the perineum is marked by a conspicuous raphé extending from the anus to the root of the scrotum. The point of junction between a line connecting the tuberosities of the ischium and the raphé is called the *perineal centre*, and serves as a convenient point of comparison in describing the component parts of the perineum.—In the *female* the perineum, as in the male, includes the anus and the muscles inserted into it, but, instead of including any portion of the genitals, ends at the posterior margin of the vulva.

The perineum of the male is divided by the surgeon into two regions by an imaginary transverse line uniting the ischial tuberosities. The region in advance of the line is called the anterior perineum or the perineum proper; the region back of the line is called the posterior perineum.

(*a*) The *anterior* or *true perineum* is the genito-urinary portion of the pelvic outlet. It includes the membranous, muscular, and other structures occupying the sub-pubic arch. The form is that of a triangle whose base is directed backward. It presents two layers, an anterior and a posterior—the two being traversed by the membranous portion of the urethra, bloodvessels, and nerves. Surrounding the urethra within these layers is the Transversus Perinæi Profundus and the Constrictor Urethræ muscles, and imbedded among the fibres of the latter are the glands of Cowper.

From the great interest attached to this region in the operations upon the neck of the bladder and the membranous portion of the urethra, in the male, the true perineum has been elaborately studied as an arti-

[1] In a classification of muscles, p. 246, the muscles of the genital apparatus or the perineum are placed in the fourth or last section, and include the muscles of the anal region and those of the genito-urinary tract.

Those of the third section, viz., the muscles of the larynx, are described under the section treating of that organ. The muscles of the present group may for convenience be considered as a sixth section of the classification presented.

ficial region having boundaries different from those which have been named.

The perineum of surgical anatomy is a triangular plane lying between an imaginary line connecting the ischial tuberosities posteriorly, and the root of the scrotum anteriorly. Laterally it is without exact limitation, unless the position of two imaginary lines passing from the ischial tuberosities to the root of the scrotum can be such, and is continuous with the median surfaces of the thighs.

The gynecologist speaks of the perineum of the female as the superficies lying between the anus and the posterior angle of the vulva. The structures underlying it enter into the composition of the recto-vaginal septum.

(*b*) The *posterior perineum* includes the region of the anus, and the spaces between the rectum and the ischial tuberosities. The first of these is commonly called the *anal region*, and the second the *ischio-rectal fossa* of each side.

The *anal region* may be defined to be the space answering to the embrace of the Sphincter Ani muscle.

The *ischio-rectal fossa* is the space between the Levator Ani muscle and the pelvic fascia covering the Obturator Internus muscle of its own side. It is open beneath, where it communicates with the gluteal region. It is occupied by fat.

1. The Muscles of the Perineum.

(See Plates illustrating the Genito Urinary Organs.)

The muscles of the perineum are divided into a genito-urinary and an anal group.

The Genito-Urinary group embraces—

- The Transversus Perinæi Superficialis.
- The Bulbo-Cavernosus.
- The Ischio-Cavernosus.
- The Transversus Perinæi Profundus.
- The Constrictor Urethræ.

The Anal group embraces—

- The Sphincter Ani.
- The Levator Ani.
- The Ischio-Coccygeus.

THE TRANSVERSUS PERINÆI SUPERFICIALIS MUSCLE.

The Transversus Perinæi Superficialis is a delicate and somewhat inconstant structure. It arises from the inner surface of the pubic arch, and is inserted together with its fellow of the opposite side at the perineal centre. The muscle lies beneath the deep layer of the superficial perineal fascia, and directly in front of the line of its union with the fascia propria. It is sometimes continuous by some of its fibres with the Sphincter Ani.

Function.—Both muscles acting together tend to elevate the perineum. They are both active at the close of defecation (hence the name of Levator Ani Parvus sometimes given them) and of parturition. In the male they assist in the expulsion of semen by the elevation of the perineal tissues against the prostate gland and the bulb of the spongy body.

Fig. 81



A. Bulbo-cavernosus muscle. B. Ischio-cavernosus muscle. C. Transversus perinæi superficialis. D. Levator ani. E. Gluteus maximus. G. Crus penis. H. Urethra. *a*. Transverse perineal artery. *b*. Superficial perineal artery. *c*. Branch of sciatic artery. 1. Inferior hæmorrhoidal nerve. 2, 3. Superficial perineal nerve. 4. Inferior pudendal nerve.

THE BULBO-CAVERNOSUS MUSCLE.

The Bulbo-Cavernosus muscle (Bulbo-Urethralis, Accelerator Urinæ, Ejaculator Seminis) surrounds the bulb of the urethra apparently as a single muscle, which is found on careful inspection to be divided by a raphé into two muscles. Each lateral portion or muscle arises not only from the raphé but from the perineal centre. It passes thence forward and outward by oblique fibres, and is inserted posteriorly into the triangular ligament, and anteriorly (by ascending between the crus and the bulb of the urethra) it is inserted upon the back of the spongy body. A few variable slips reach the dorsum of the penis where they are continuous with the aponeurosis of that organ.

Function.—In the unerected penis the muscle assists in voluntarily expelling the urine from the urethra at the end of micturition. In the erected organ it aids in maintaining the erected state chiefly by the compression of the veins of the bulb, and less constantly by the tension of the aponeurosis of the

dorsum of the penis, thereby compressing the dorsal veins. It also involuntarily expels the semen left in the urethra at the close of coition.

Remarks.—The description of the muscle as given is based upon a dissection made from below, that is from the perineum. It is in every way probable that a reversal of the description would be more appropriate. Fibres arising from the triangular ligament and the dorsum of the cavernous body, *inserted* upon the raphé, would be well adapted to compress the bulb, while no motion could ensue from fibres inserted on a fixed structure like the triangular ligament.

THE ISCHIO-CAVERNOSUS MUSCLE.

The Ischio-Cavernosus muscle (Erector Penis) arises from the median aspect of the ascending ramus of the ischium, immediately in advance of the tuberosity, and in close association with the crus of the penis. It passes forward and is inserted upon the outer side of the cavernous body. An inconstant slip passes upward to meet its fellow of the opposite side at the median line of the dorsum of the penis.

Function.—In the unerected penis the muscle retracts the root of the penis. In the erected organ, it aids in maintaining erection. It is doubtful whether this muscle in any way initiates erection. In the female a muscle analogous to the foregoing (Ischio-Clitoridis) arises from the ischium and is inserted upon the clitoris.

THE TRANSVERSUS PERINEI PROFUNDUS.

This muscle occupies the base of the triangle between the tuberosity of the ischium and the Bulbo-Cavernosus muscle. It arises from the side of the descending ramus of the pubis as a loosely fasciculated layer, whose fibres are inserted some over and some under the membranous portion of the urethra, embracing the glands of Cowper.

Function.—This muscle aids the Bulbo-Cavernosus.

THE CONSTRICTOR URETHRÆ.

The Constrictor Urethræ muscle surrounds the urethra more intimately than does the preceding. It arises from the layer of fascia extending between the pubis and the prostate gland, known as the pubo-prostatic ligament. The fibres split into an anterior and a posterior set inclosing the urethra between them.

A delicate fascicle passing from the posterior surface of the pubis to the neck of the bladder has received the name of the Pubo-Vesical muscle.

Both of the above-named muscles are considered by Luschka to be parts of a single muscle which he describes under the name of Musculus Urethralis Transversus.

Function.—The muscles act together in compressing the urethra, and thus assist the action of the Bulbo-Cavernosus. They resist the sudden introduction of a catheter.

M. Cadiat,[1] as a result of an elaborate study of the muscles of the perineum, states that the so-called muscles of Wilson and Guthrie are best included within a muscular layer which permits of the following description. There exists in the perineum between the anal sphincter and the circular fibres about the urethra (included here in the two muscles last described) an arrangement of imperfectly specialized transverse muscular fibres of variable form. These fibres are in part inserted into the raphé, in part are continuous with the Bulbo-Cavernosus muscle, and in part serve as subdermal fasciculi, and like such fibres are not properly described from the standpoints of origin or insertion, but are related to the different bands of connective tissue. None of the fibres exert any action upon the venous circulation.

THE SPHINCTER ANI.

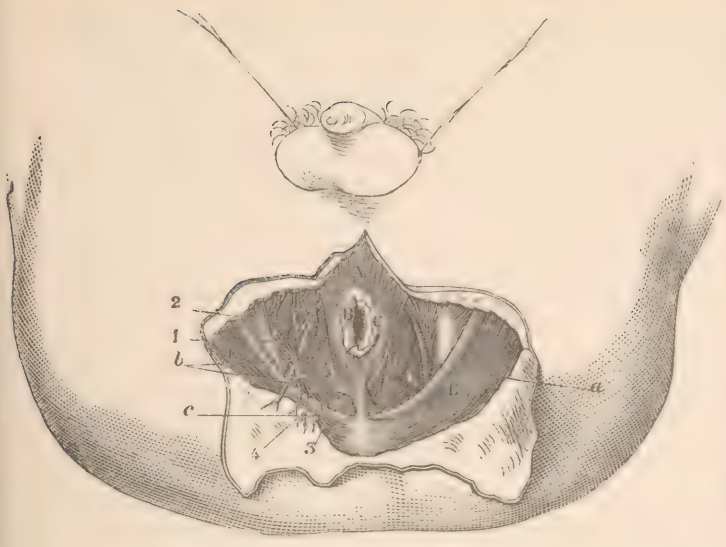
The Sphincter Ani muscle (External Sphincter, see illustrations of the genito-urinary apparatus) arises from the tip and the adjacent surface of the coccyx, passes forward, and, surrounding the anus by a thick bundle measuring about one-half an inch in width, is inserted into the perineal centre directly behind the Bulbo-Cavernosus muscle. Some of the marginal fibres are continuous with those of the last-named muscle. In the female the anterior fibres interlace and are lost within the Constrictor Vaginæ muscle.

Function.—To constrict the anus.

Remarks.—The Sphincter Ani belongs to the skin layer of muscles, and in a strict sense cannot have any important association with the skeleton. Leidy, indeed, describes it as arising from the subcutaneous tissue at the end of the coccyx.—A small bursa is sometimes found between the fibres of origin and the coccyx.—It is of importance to ascertain the condition of this muscle in studying many morbid conditions of the anus. It is relaxed in prolapsus of the rectum and in that condition of the parts which is associated with hæmorrhoids. Absolute rest of the anus—a state demanded by the surgeon in his attempts to relieve the distress arising from anal fissure and fistule—is secured by division of the muscular fibres

[1] Journ. de l'Anat. et de la Phys. 1877, 39.

Fig. 82.



A View of the Dissection of the Posterior Perineum of the Male.—A. The sphincter ani (external portion). B. Fibres of the same at the anal orifice. D. Levator ani. E. Gluteus maximus. *a*. Pudic artery. *b*. Inferior hæmorrhoidal artery. *c*. Branch of the sciatic artery. 1. Inferior hemorrhoidal nerve. 2. The superficial perineal nerve. 3. The perineal branch of the fourth sacral nerve. 4. The small sciatic nerve.

surrounding it. The muscle may be ruptured by forcible dilatation from side to side. This procedure will take the place of division under some circumstances, and greatly facilitate operations within the rectum, and it will enable the operator to explore the deeper parts with the hand.

THE LEVATOR ANI.

The Levator Ani is a thin sheet-like muscle lying upon the side of the true pelvis. Its somewhat extended line of origin embraces the horizontal ramus of the pubis between the upper and the lower borders, a small portion of the descending ramus of the pubis, the upper border of the pelvic fascia as it lies between the Obturator Internus muscle (arcus tendinosus), the spine of the ischium, and the lesser sacro-sciatic ligament. The anterior fibres (Levator Prostati) are inserted at the base of the bladder and about the prostate gland. The fibres arising from the pelvic fascia pass downward and inward toward the rectum, with the coats of which they are incorporated near the Sphincter Ani. The posterior fibres arising from the spine of the ischium pass downward and inward, and, approaching one another, are inserted in a raphé extending from the tip and sides of the coccyx to the anus.

Function.—The Levator Ani muscles form a diaphragm across the inferior pelvic strait which supplements in respiration the thoracic diaphragm. When the motions of the last-named structure are impaired, as in the fixation of the lower ribs from a dressing for fractured rib, or in the use of the plaster jacket, the perineum, through the agency of the Levator Ani muscles, is seen to rise in expiration and descend in inspiration. The muscle also aids in the act of defecation and in supporting the pelvic viscera. The membranous surfaces affording origin to its fascicles are rendered tense by the act of squatting, owing to the continuity of these membranes with the lines of origin of the Biceps Flexor Femoris.

Relations.—The Levator Ani muscle is covered below the *arcus tendinosus* by the pelvic fascia, which thus separates it from the peritoneum. Below the fascia separates the muscle from the bladder and rectum in the male, and from the rectum and vagina in the female.

Nerve.—The Levator Ani is supplied by branches of the fourth sacral nerve.

THE ISCHIO-COCCYGEUS.

The Ischio-Coccygeus muscle arises by a broad base from the tip and side of the coccyx and a small portion of the sacrum. It passes outward, its fibres converging as it does so, to be inserted into the spine of the ischium and in part upon the lesser sacro-sciatic ligament. Its anterior border is nearly continuous with the posterior fibres of the Levator Ani.

Functions.—The muscle aids in supporting the pelvic viscera. When both muscles act together they may draw the coccyx slightly forward, and thus lessen the antero-posterior diameter of the inferior strait of the pelvis.

The Ischio-Coccygeus is homologous with the lateral tractor of the tail in the Quadrumana.

Nerve.—The Ischio-Coccygeus is supplied by a branch of the fourth sacral nerve.

2. The Fasciæ of the Perineum.[1]

The fasciæ at the inferior outlet of the pelvis may be studied (1) from above, *i. e.*, from within the pelvis, or (2) from below, *i. e.*, from the skin surface.[2]

(1) *The perineum studied from above.*

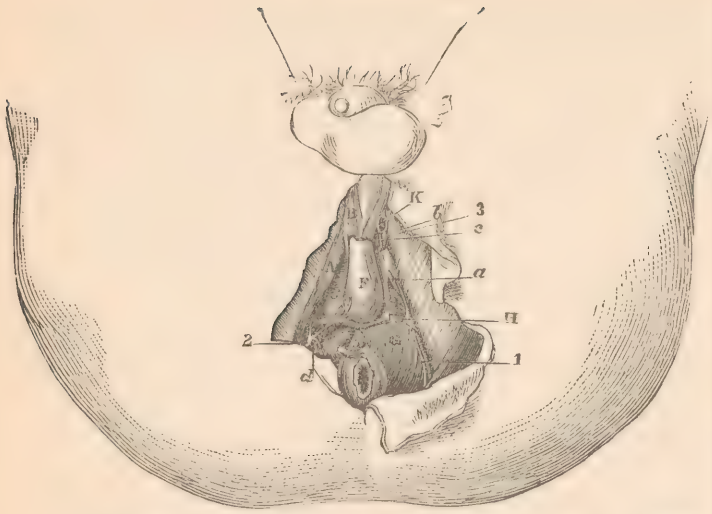
Under this head are included two fasciæ as follows:—

The Obturator Fascia.
The Pelvic Fascia.

[1] For convenience the descriptions of the anus and of the ischio-rectal fossa are included in this section.

[2] This division of the structures at the outlet is shown to be correct by a study of the development of the parts. The pelvic organs are sustained by structures which are common to the abdominal cavity. The skin, the perineal fasciæ and muscles, as opposed to these, are *tegumentary* structures.

Fig. 83.



DEEP DISSECTION OF THE PERINEUM.—A. Ischio-cavernosus muscle. B. Bulbo-cavernosus muscle. C. Triangular ligament. D. External portion of sphincter ani muscle. F. Bulbous portion of the urethra. G. Levator ani muscle. H. Transversus perinei profundus. I. Fibres of the same constricting the urethra. K. Section of the crus penis. *a*. Internal pudic artery. *b*. Dorsal artery of the penis. *c*. Artery of the cavernous body. *d*. Deep muscular and urethral branch. 1. Pudic nerve. 2. Muscular branch of the same. 3. Dorsal nerve of the penis.

The *Obturator Fascia* is the proper fascial covering of the Obturator Internus muscle. It lines the wall of the true pelvis, receives the pelvic fascia from above, gives origin to the Levator Ani muscle, and is connected with the lateral margin of the deep perineal fascia and the anterior layer of the triangular ligament.

The Pelvic Fascia.—This membrane forms the subperitoneal fascia of the pelvic organs Like the subperitoneal connective tissue with which it is continuous, the pelvic fascia is loose where it lies near the peritoneum. But as it reaches the lower part of the pelvis, and particularly as it advances to the anterior portion, it becomes thicker, until in the neighborhood of the pubis and the prostate gland it is aponeurotic in structure.

The pelvic fascia is composed of two portions, a parietal and a visceral.

The *parietal portion* or *layer* extends from the iliopectineal line to the origin of the Levator Ani muscle, and from the pubis to the great ischiatic notch. It lies in contact and is incorporated with the obturator fascia as well as with the side of the prostate gland and the rectum. Posteriorly, the pelvic fascia crosses the Pyriformis muscle and is united to the anterior surface of the sacrum by four or five slips. Each interspace between the sacrum and the fascia is occupied by a ganglion of the sympathetic nerve. Below, the fascia is intimately associated with the anterior sacro-coccygeal ligament.

The *visceral portion* or *layer* consists of slips or bands from the parietal layer, which, passing downward, embrace the deep pelvic viscera. The bands are: (*a*) The median and lateral true ligaments of the bladder. These are small slips arising from the parietal layer at the pubis and passing to the lower portion of the bladder. (*b*) The posterior layer of the triangular ligament. This arises from the posterior lip of the pubic arch, and passes thence downward; it is pierced by the membranous portion of the urethra, by the dorsal vein of the penis, by the artery of the penis, and by the dorsal nerve. Bands extending from it along the sides of the prostate gland and the neck of the bladder form the so-called *ligamentum pubo-prostaticum* and the *ligamentum pubo-vesicale.* (*c*) A fascial envelope of the prostate gland continuous with the foregoing, and passing backward to the sides of the bladder and the rectum. This is an important layer, since it embraces the prostatic plexus and is divided in lithotomy. (*d*) A layer (recto-vesical fascia) passing below the prostate gland and extending upward and backward between the rectum and the bladder, separating these viscera and embracing the vesiculæ seminales. According to Denonvilliers, it is continuous with the peritoneum, and forms the *prostatico-peritoneal* ligament. (*e*) A slip from the ischium to the prostate gland. (*f*) A slip from the parietal layer which joins its fellow of the opposite side behind the rectum.

(2) *The perineum studied from beneath.*

The skin of the perineum is marked in the median line by a raphé.

The fasciæ are three in number:—

The Superficial Fascia.
The Fascia Propria.
The Pelvic Fascia.

The Superficial Fascia is composed of two layers: The *first layer* is continuous with the superficial fascia of the trunk and the limbs. It can be traced anteriorly into the dartos of the scrotum, and posteriorly, by means of the fat within its meshes, into the ischio-rectal fossa.

The *second layer*, also called the *deep perineal fascia*, is membranous, and serves as an aponeurosis to the Ischio-Cavernosus, the Bulbo-Cavernosus, and the Transversus Perinei muscles. It is attached to the sides of the inferior outlet of the pelvis as far back as the transverse imaginary line, where it becomes thin, and is lost in the perineal centre. It is here continuous above with the fascia propria. Anteriorly the

second layer is continuous with the sheath of the penis.

The Fascia Propria is a firm unyielding membrane filling in the inferior strait of the pelvis at the pubic arch, and in part continuous posteriorly at the perineal centre with the second layer of the superficial fascia. It is composed of two layers, the anterior and posterior. The *anterior layer* is lost inferiorly on the bulb of the spongy body, and is pierced by the urethra. The *posterior layer* is continuous with the ligamentous bands of the pelvic fascia supporting the prostate gland. The interval between the layers, answering to the thickness of the abutments of the pubic arch, is occupied by the membranous portion of the urethra, the Compressor Urethræ and deep Transversus Perinei muscles, and the glands of Cowper.

The anterior layer of the fascia propria is divided in lithotomy. The *triangular ligament* is a term in general use to signify that portion of the fascia propria supporting the prostate gland and the membranous portion of the urethra.

The *triangular ligament* is a membrane formed in front by a fascial expansion answering to a process of the deep perineal fascia, and behind by the pelvic fascia. The anterior layer unites, behind the Superficial Transverse Perineal muscle, with the deep perineal fascia and with a thin anal fascia extending backward. It would be unwise to attempt to ignore a term that has been in general use so long, although it is necessary to remember that the membrane so named is not a true ligament, and has no distinctive anatomical value.

The pelvic fascia underlies the fascia propria as already described (p. 330, 2d col.).

The posterior perineum embraces—
The Anal Region.
The Ischio-Rectal Fossa.

The Anal Region (ischio-rectal region). The space thus named extends from the coccyx to the posterior border of the Transverse Perinæi Superficiales muscles. On either side it is defined by the median border of the Gluteus Maximus muscle. The region includes the *anus* and the ischio-rectal fossa.

The *Anus* is the outlet of the rectum. It is a closely constricted orifice, lined with mucous membrane within and with integument without. Coarse hairs and a number of sebaceous glands are found about its borders.

The Ischio-Rectal Fossa is defined within by the under surface of the Levator Ani muscle, without by the obturator fascia, and below by the origin of the last-named muscle as well as by the Ischio-Coccygeus muscle.

The fascia of the under surface of the Levator Ani joins the obturator fascia above. Below, it is continuous as a thin layer over the External Sphincter Ani, and is lost anteriorly on the deep perineal fascia. This membrane is the ischio-rectal fascia of some authors. The fossa is filled with fat, which is continuous with that of the buttock.

Remarks.—The perineum is a region within which occur many lesions of practical importance.

The superficial structures may be the seat of *abscess*, which, as a rule, is situated in the anterior perineum only.

The connective tissue beneath the second layer of the perineal fascia and between the two Bulbo-Cavernosi muscles may become the seat of localized inflammation due to traumatic irritation transmitted from the urethra, and often breaks down, forming an *abscess* at a point answering to the perineal raphé. Rarely the pus passes forward to involve the sheath of the penis, but never backward beyond the perineal centre, on account of the union of the second layer of the perineal fascia with the fascia propria.

When pus forms in the space between the two layers of the fascia propria, it meets with less resistance backward and outward than elsewhere, and is apt, therefore, to flow toward and into the posterior portion of the perineum, either superficially at the side of the anus or more deeply seated at the sides of the rectum. One of the most frequent instances in which pus is found occupying this space occurs in *prostatic abscess*. This abscess may thus be sought for by rectal examination, the pus being frequently found directly in front of the anterior wall of the rectum.

In rapidly formed *urinary infiltration*, occurring in advance of the fascia propria, the fluid, guided by the second layer of the perineal fascia, extends forward to the sheath of the penis, and thence to the scrotum and the superficial fascia, by means of which it can be easily conducted to the abdomen. Owing to the union existing between the second layer of the perineal fascia and the fascia propria no infiltration occurs posteriorly about the anus.

If urinary infiltration occurs between the layers of the fascia propria, the urine flows backward, as in the case of the pus in an abscess in the same situation.

Fracture of the pelvis involving the attachment of the fascia propria necessarily lacerates the soft parts lodged between the two layers. Urinary infiltration

into the perineum and *diffuse cellulitis* are in this way liable to occur.

The ischio-rectal fossa is a frequent site of *abscess* and of *fistulous* tracks extending thence from the rectum. In the course of wasting diseases—notably pulmonary consumption—the fat occupying the fossa is absorbed, and the region appears, under the altered condition resulting from the absorption, to be liable to attacks of inflammation and abscess. Extensive infiltration may cause large irregular abscesses to form in the posterior perineum, which, however, as a result of the union existing between the fascia propria and the second layer of the perineal fascia, never involve the anterior perineum.

ON DISPLACEMENTS IN FRACTURE.

After a fracture in any of the movable bones, the action of the muscles connected with the fragments, conjoined to the weight of the limb or adjacent parts, is liable to produce displacements. These are distortions of the axis of the broken bone. The displacement depends, among other things, upon the direction of the fracture. It is more decided in oblique than in transverse fractures, and also holds a direct relation to the development of the muscles attached to the fragments.

The brief account here given of these displacements is not intended to include all the possible forms, but to give those which may be said to be typical. For the unusual forms of displacement, and the explanations of them, the student must consult the elaborate works on surgery.

The Lower Jaw.—In the fracture of the lower jaw at the anterior third of the horizontal portion, the short fragment is elevated, and turned slightly inward by the Temporal, Masseter, and Internal Pterygoid muscles. The larger fragment remains nearly stationary, or is drawn slightly downwards by the depressors of the lower jaw.

When the mental portion is separated by a fracture on each side of the incisorial portion, the middle fragment is drawn forcibly downward by the Genio-Hyoid and Mylo-Hyoid muscles, and, if the detached portion includes the digastric fossa, by the Digastric muscle. The lateral fragments are elevated and drawn inward.

Fracture of the Clavicle.—In all fractures of the clavicle, the weight of the superior extremity tends to pull the outer fragment downward, the displacement being modified by the mobility of the scapula. The most common location of fracture in this bone is at the outer end of the middle third. The weight of the superior extremity here causes the outer fragment of the bone to fall below the level of the inner fragment, which is held in position by the rhomboid ligament and the Subclavius muscle. Some writers believe that the inner fragment may be slightly elevated by the Sterno-Cleido-Mastoid muscle. In addition to its downward traction, the outer fragment is ordinarily drawn in toward the chest, as well as slightly forward, by the Subclavius and Pectoral muscles. It may be drawn slightly backward as well as downward by the muscles holding the scapula and humerus backward, viz., the Serratus Magnus, the Latissimus Dorsi, and possibly by the Rhomboideus.

When the fracture occurs near the sternal end, the outer fragment behaves as in fracture at the middle third. The movements, however, are restricted by the pressure of the first rib immediately beneath and behind the inner end of the outer fragment. The fragment cannot pass backward or downward by reason of the position of this rib, and hence forms a forward projection. The sternal fragment is not deflected.

When the fracture is at the point of the bone answering to the interval between the fibres of the coraco-clavicular ligaments or between the ligaments and the acromial end, little or no displacement occurs. It is limited to an alteration in the direction of the bone by which the natural convexity of this portion of the clavicle is increased.

When the lesion is between the trapezoid ligament and the sterno-clavicular articulation, the displacement of the outer fragment is considerable. When the lesion is to the sternal side of the rhomboid ligament, the acromial fragment alone is ordinarily displaced; since muscular action, the weight of the upper extremity, and the mobility of the scapula all combine to depress the acromial portion, and press

forward its sternal end (the first rib preventing its moving backward), while the sternal fragment remains in the normal position.[1]

The Scapula.—Fracture of the acromion. The Deltoid draws the detached fragment downward and forward.

The coracoid process. The detached portion is drawn downward by the Coraco-Brachialis and the short head of the Biceps muscle, and downward and inward by the Pectoralis Minor. As a result of the severance from the scapula the fragment moves with the humerus in manipulation of the parts.

The Humerus.—The greater tuberosity. The fragment is pulled backward by the Supra-Spinatus, Infra-Spinatus, and Teres Major muscles. The lower fragment is drawn inward by the Subscapularis, and forward by the Pectoralis Major.

The surgical neck. The displacement is confined for the most part to the lower fragment. The sternal portions of the Pectoralis Major, the Latissimus Dorsi, and Teres Major muscles draw the arm toward the chest.

The shaft of the humerus is drawn obliquely outward by the Deltoid, so that the upper fragment tilts toward the axilla; this is possible from the fact that no fibres of this muscle are inserted above the deltoid ridge. Once in this oblique position, the lower fragment is pulled upward, and maintained in this position by the muscles passing from the scapula to the humerus or bones of the forearm, viz., the long head of the Triceps, the Biceps, and the Coraco-Brachialis. The upper fragment moves but little. It may be slightly tilted and elevated. The same kind of displacement, differing in degree only, will be recognized in any fracture of the shaft above the insertion of the deltoid muscle. The displacement is least marked in a moderately oblique fracture, the compact muscular masses about it being well in the embrace of the fascia of the arm, which acts as a bandage, keeping the fragments in position.

When the fracture exists at the lower third of the shaft, the lower fragment ordinarily slips upward behind the upper and toward the inner side, the Triceps being the chief factor in the displacement, the Biceps and Brachialis Anticus assisting.

Fracture of internal epicondyle. The fragment is drawn slightly downward and outward (*i. e.*, toward the forearm) by the flexor mass.

The Radius.—The neck. The forearm being extended, the Biceps muscle would rotate the lower fragment outward and upward. The upper fibres of the Supinator Brevis have been charged (probably on theoretical grounds) with rotating the upper fragment outward. In fact, the fracture is so deeply seated that the displacement (if any) is difficult to make out. The lesion is an exceedingly rare one. When the bone is fractured a short distance below the insertion of the Pronator Radii Teres, the upper fragment is pulled upward by the Biceps muscle at the same time it is rotated inward by the Pronator Teres. The lower fragment is drawn ulna-ward by the Pronator Quadratus, a movement which is aided by the tilting upward of the distal end by the Supinator Longus.

When the bone is fractured at the lower extremity, either at or immediately above the wrist, a characteristic deformity results. The most conspicuous appearance seen is an adduction of the hand, and an undue prominence of the styloid process of the ulna. These signs have a single cause, viz., the extensors and the flexors of the carpus, and the extensors of the thumb (which normally have but slight power in adducting the hand) exerting inordinate action upon the radial border of the hand. The adduction is exaggerated when the internal lateral ligament and the triangular cartilage are ruptured.

In addition to the above, a broad prominence is seen on the dorsum of the forearm a short distance above the wrist, due to the over-riding of the lower fragment upon the upper. In the instances where the fracture has followed a fall upon the hand (including the greater number met with in practice) the lower end of the the upper fragment is violently driven forward into the substance of the Pronator Quadratus.

The Ulna.—The ulna when fractured at or near the centre usually exhibits a slight deformity dependent upon the lower fragment being drawn towards the radius by the Pronator Quadratus, the upper fragment remaining at rest.

When the coracoid process is fractured, the severed tip is drawn upward by the Brachialis Anticus, and flexion of the elbow joint is impaired. Should the fracture have occurred at the base of the process, the ulna is dislocated backward by the traction of the Triceps muscle.

When the olecranon is fractured, the fragment is drawn upward by the Triceps, and is hence above the line of the epi-arthritic processes. Extension of the elbow is partially destroyed, while flexion makes the depression between the olecranon and the shaft pronounced.

[1] R. W. Smith, Dublin Journ. Med. Sci., l., 1870, 8.

Dislocation of Sternum.—The gladiolus is lifted up and carried in advance of the manubrium by the force transmitted to it from the ribs, the manubrium remaining fixed by the first and second ribs. W. Rivington,[1] in describing a lesion of this character, which resulted from a bag of seed falling from a height of forty feet upon the trunk between the shoulders, conceives that the shock of the blow had been received by the six or seven upper dorsal vertebræ, and transmitted by the true ribs to the sternum, driving that bone forward. Owing to the greater mobility and leverage of the five lower true ribs, the gladiolus was acted upon more powerfully than the manubrium, and the result was that the strain fell on the structures uniting the two segments, and that the gladiolus was pressed forward in front of the manubrium.

Fracture of the Sacrum.—When the lesion is transverse and at the lower portion, the lower fragment may be drawn forward by the Gluteus Maximus, Coccygeus, and Sphincter Ani muscles.

The Coccyx.—Similar forces to those above cited will cause the detached portion to be drawn forward.

The Femur.—Fracture of the neck. The lower fragment is drawn upward by the gluteal muscles, aided by the Rectus Femoris and the hamstrings, and inward by the Pectineus, Iliacus Internus, and Psoas Magnus, and the Obturator Internus, aided by the adductor muscles. The eversion of the limb ordinarily resulting from this lesion has been explained on theoretical grounds as the result of the action of the Obturator and Pyriformis muscles, together with the Iliacus and Psoas. The tendency for the foot to turn out is more easily referred to the weight of the foot, and takes place as readily in states of unconsciousness or after death as when the muscular system is active.

Fracture below the trochanter minor. The upper fragment is tilted forward by the Iliacus Internus and Psoas Magnus, and rotated outward by the Gluteal muscles and the external rotators. The lower fragment is drawn upward by the adductor, hamstring, and Rectus Femoris muscles. The eversion of the limb is owing to the same causes as in fracture of the neck.

Fracture in the middle third. The upper fragment, as in the foregoing lesion, lies in advance of the lower, owing to the operation of the same causes, viz., the tilting of the upper fragment by the Iliacus and Psoas. At the same time the Adductor Magnus and Gastrocnemius draw back the lower fragment. Shortening occurs from the traction of the Rectus and hamstring muscles.

Fracture in the lower third of the femur. The upper fragment, as in the other examples of fracture of the shaft, lies in front of the lower, and is drawn slightly inward. The lower fragment is drawn backward toward the ham by the Gastrocnemius muscle. The displacement is slight. Some writers give undue prominence to its amount, while others deny its occurrence under any circumstances. It is generally held that the two Vasti muscles also materially aid in the backward tilting of the fragment.

Congenital Dislocation.—The flexed femur in the fœtus presses upon the posterior and inferior portion of the acetabulum. While in this position, according to Dr. Carnochan,[1] the bone is moved by the muscles which arise from the pelvis and are inserted in or about the trochanter. The Glutei being the more powerful of these muscles have a tendency by undue contraction to drag the head of the femur upon the dorsum of the ilium, thus creating a congenital dislocation of the hip.

The Patella.—In fracture of the patella the upper fragment is drawn upward by the Quadriceps Femoris muscle.

The Tibia.—Fracture of the shaft of the tibia at the superior or middle third prevents displacement of the fragments which vary according to the obliquity and direction of the opposed surfaces. The upper fragment often presents anteriorly and has been described as tilted forward by the Quadriceps Femoris. Such a motion, however, is exceedingly slight, and at best is not enough to account for the position. The shortening of the limb by the Gastrocnemius muscle and the slipping upward of the tip of the oblique surface of the lower fragment behind the upper, thus pushing it forward, is a much more rational explanation. But the lower fragment may be in front and to the outer side of the upper; the fibres of the Gastrocnemius and Soleus muscles being responsible for the traction. The peroneal muscles may draw the foot slightly outward.

In fracture of the fibula with lateral subdislocation of the ankle, the peroneal muscles strongly abduct the foot and tend to evert it.

[1] Med. Chir. Trans., lviii., 106.

[1] Congenital Dislocation of the Hip, New York, 1850.

ALLEN'S

HUMAN ANATOMY.

ARTERIES, VEINS AND LYMPHATICS.

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THE HEART AND THE BLOODVESSELS.

GENERAL CONSIDERATIONS.

THE heart and bloodvessels compose the blood-vessel system. This system embraces all the organs, tubes, or channels through which the blood flows, as well as the various appendages to the bloodvessels.

The heart is a hollow muscular organ pertaining to both the arterial and venous systems. It is a duplex pump, each half of which is a modified bloodvessel.

The bloodvessels proper are divided into the arteries, veins, and capillaries; each of these groups forming in turn a separate system.

The bloodvessels are otherwise divided into two systems: the *pulmonic*, or the system of vessels by which blood is carried to and from the lungs for the purposes of respiration; and the *systemic*, that by which blood is carried to and fro through the body. The term "circulation" is more frequently employed in this sense than "system." Thus we speak of the "pulmonic circulation," the "systemic circulation," and the "fœtal circulation."

Capillaries.—Capillaries are networks of minute vessels, in the meshes of which are arranged the elements of the tissues. The capillary vessels in their simplest form are composed only of the lining membrane of the larger vessels. They are thin and cellular, and here and there openings appear between the cells, which constitute the so-called *stomata*. A tendency exists for the white blood-corpuscles to escape through these openings into the extra-vascular tissue-interspaces. This act is called *diapedesis*, and plays an important part in the nutritive processes.

The transition from a capillary vessel to either a vein or an artery is gradual, the simple cellular tube taking on the several coats of the more complex structures.

The capillaries of the face, the vault of the cranium, the tongue, the skin, the joints, the plantar and the palmar regions exhibit some structural peculiarities, and have been designated by M. Péan the arterio-venous system.[1]

The arteries and veins do not always communicate by a capillary network. In some portions of the body, as in the fingers and toes, the elbow, the knee, and, in a less degree, in the skin of the face, at the lips, nose, eyelids, and ears, as well as in the mucous membrane of the nasal septum, the two sets of vessels join directly one with the other.

Capillary vessels form loops or meshes of various shapes and sizes. They are rhomboidal in nerve-tissue and looped in cartilage as it joins the end of the long bones, etc.

Rete Mirabile.—The plan of a capillary network may be repeated on a large scale, so as to form a coarse network, or the separate arterial and venous stems may form a network of vessels. Such local expressions constitute the different forms of *rete mirabile*. Examples are seen in the pia mater, and the choroid plexuses of the brain.

Erectile tissue is characterized by the possession of *rete mirabile* in which the blood-canals are varicose, and appended in great part to the venous system. In typical expressions of erectile tissue, as in the penis, the arteries are small, are supported by septæ, and do not contribute to a capillary network. Under certain conditions of the nerves and muscles of the part, the venous spaces, ordinarily containing but little blood, hold relatively enormous quantities, and thus cause the organ to enlarge, or, to use the more common word in use, to become erected. Other examples of erectile tissue are seen in the nipple and the mucous membrane covering the turbinated bones.

[1] Sacquet, Bull. de l'Acad. Méd. 1856, 144.

Many if not all forms of nævus and arterio-venous aneurism are defects in the disposition of the capillary system. They may occur in any part of the body, and may even be developed in the stump of an amputated limb. Mr. Adams[1] has recorded an example of extraordinary enlargement of all the bloodvessels of the lower extremity. Death occurred from hemorrhage.

Arteries.—Some degree of propulsion as well as the conduction of the blood is included in the functions of the arteries. Owing to the elastic character of the walls these vessels can be stretched without injury far beyond the position they assume when at rest. They also aid in protecting the larger viscera, as well as in sustaining important organs in position. The heart is held in place by the aorta; the kidney, in part by the renal arteries and the aorta; and the jejunum and ileum, by the mesenteric vessels.

Arteries frequently lie in large spaces between sets of muscles; *i. e.*, between the flexors and the extensors, the extensors and the adductors, etc.

They also often lie between the superficial and the deep muscles of the same set. These lines are probably predetermined by nerve trunks, since even the recurrent arteries about the joints are apt to follow the track of a nerve in their ascent. Thus the radial recurrent artery runs back along the track of the musculo-spiral nerve, and the posterior ulnar recurrent artery, along that of the ulnar nerve.

The main arteries of a limb lie in company with its main veins, and are inclosed in the same sheath.

The size of a given artery is proportionate to the amount of work done in the part to which it is distributed. The glands, with the exception of the testis, have very large bloodvessels as compared with the muscles and the bones. The brain is one of the most vascular of organs. The size of the renal and the mesenteric arteries as compared with the parts within which they are distributed is enormous. The bloodvessel-glands, such as the spleen and the thyroid body, also receive relatively large volumes of blood.

The ultimate arrangement of the bloodvessels varies according to the nature of the organ within which they lie. In the limbs the arteries are arborescent and form few large anastomoses. In the brain they are tortuous and the larger trunks anastomose freely, while many of the smaller terminal ones end in brush-like expansions without anastomosing. Such arteries are said to be *penicillated.* Again, two portions of the brain, as the cerebrum and the cerebellum, may differ in this regard.

Arteries are tortuous in passing through mobile regions, such as the face; or toward the spleen, an organ subject to great changes in size.

The arteries and veins of the skull often lie in spaces between ossific centres. Such spaces between imperfectly developed bones are apt to contain small bloodvessels in transit, which by their presence prevent the completion of the ossifying process.

T. W. Nunn[1] believes that the arteries of the extremities preserve a uniform arrangement, and that their irregularities or varieties of distribution are in definite relation with this general plan. He thus calls the profunda femoris a *segmentary* artery, since it is designed to nourish that segment of the limb lying between the hip and the knee. The superior and inferior profunda of the upper arm, the interosseous artery of the forearm, and the peroneal artery are in like manner segmentary arteries to their respective regions of the extremities. It will be observed that all these vessels arise from the main vessel at a considerable angle, and rapidly divide into numerous branches. The term *trans-segmentary* he restricts to the main vessel traversing a segment of a limb, but giving few or no branches thereto. Such, for example, are the femoral, posterior tibial, radial, and ulnar arteries. *Anastomotic* or *communicating* arteries are those which have no special direction, but form with the corresponding vessel or vessels acute or obtuse angles. They unite the segmentary arteries, the segmentary with the trans-segmentary, the trans-segmentary arteries, or the different parts of the same trunk. The anterior tibial is called a *composite* artery, since it combines the characteristics of a segmentary and of a trans-segmentary vessel, and at the same time furnishes an anastomotic branch. Applying the plan to the arteries of the foot, he believes the internal plantar artery to represent an abortive trans segmentary vessel, and the external plantar a segmentary trunk. The former gives off few branches, while the latter divides into numerous muscular branches, like those of the segmentary arteries elsewhere. In the same way he describes the external iliac artery as a main vessel of transit, hence resembling a trans-segmentary vessel from the trunk, while the internal iliac coming from it at a large angle is the artery of supply to the iliac region and is hence analogous to a segmentary vessel of the lower extremity. He gives a hypothetical reason

[1] Med. Times and Gazette, 1857, vol. xiv. 511.

[1] Journ. de l'Anat. et de la Phys., 1874, 7.

for the occasional union of the two profundæ arteries in a common trunk, viz., that it is an attempt to repeat in the upper extremity what is normal in the lower by giving the nutrient or segmentary artery of the upper arm the same plan as that usually seen in the lower. On the other hand, the femoral profunda artery may take upon itself the normal disposition of the brachial profunda.

The *variations* in the bloodvessels are numerous, and arise either from irregular development of the parts of the body in which the variation occurs, or from imperfect absorption of fœtal or other temporary structures. When an organ normally receiving blood through a given channel is seen in an exceptional instance to receive it from another, it is reasonable to assume that owing to some temporary retardation in its development, the organ demanded little or none of the blood arriving through the accustomed channel, and the vessel became rudimentary. The organ subsequently renewing its activity of growth would be compelled to rely upon the capillaries of an adjacent vessel for its supply, and through them gradually establish an aberrant trunk of sufficient size for its purpose.—Instances of retention of temporary structures explain irregularities in the great trunkal vessels with great exactness.[1]

In a minor degree, variations of the great vessels of the thorax may be influenced both by habit and age, and by causes dependent upon defects in the curvatures of the vertebral column and the respiratory movements.—Errors of observation in the relations of bloodvessels have occasionally arisen from studying the parts in a state of over-distension, either as a result of diseased action or the unskilful use of injecting material.

While a thorough knowledge of the large bloodvessels is of the first importance, an acquaintance with the smallest twigs must not be ignored. By these apparently insignificant vessels the means are afforded by which a *collateral circulation* is established after the obliteration of the larger vessels, whether by ligation or by the pressure of morbid growths.—The smaller vessels also serve as guides in reaching the larger vessels. Thus the deep epigastric artery when traced up will lead the operator to the external iliac, the acromial artery to the axillary, and the small twigs in the intermuscular septum of the front of the leg to the anterior tibial artery.—A vessel usually small may become abnormally enlarged and be mistaken for the main vessel of the part. The deep humeral artery has in this way been confounded with the brachial artery, the anastomotica magna with the femoral and the superficial volar with the radial artery.—A small vessel arising from the side of a large trunk, as, for example, a twig arising from the femoral artery, will bleed more freely than will another of the same size arising from a small trunk. The amount of blood lost is out of all proportion to the size and the relative importance of the vessel. The same remark is applicable to the terminal twigs of a short vessel arising from a large trunk. The ranine branch of the lingual artery is an example of such a vessel.

The larger nerves and vessels of a limb are protected by the joints, and invariably lie in the lines of their flexion. Thus the axillary artery and vein are lodged within the angle formed between the scapula and the humerus; the brachial artery and the median nerve, together with the more important superficial nerves, are situated in the angle (anterior surface) between the humerus, the ulna, and the radius. Similar arrangements of parts are found in the lower extremity. The following case is of great value as an illustration of the slight degree of force required to create alarming if not fatal disturbance resulting from a blow upon a large vessel in an unprotected situation. A girl, twelve years of age, while standing erect, was struck over the groin with a stick, which was thrust up beneath the clothing by a companion. Death ensued on the third day. The femoral artery just below Poupart's ligament was found distended, and, upon dissection, showed rupture of the inner and middle coats. The walls of the femoral vein were injected, and its lumen blocked up with fibrinous deposit.[1]

The volume of blood flowing through an artery can be controlled by the position of the joint. The least amount of resistance to the flow is offered in semi-flexion. Extreme extension retards, while extreme flexion retards if it does not arrest the flow. Hence forced flexion of a joint on the proximal side of a wound is often employed to arrest hemorrhage, and to cure aneurism.

Localization of Diseased Action.—The frequency of aneurism at the bend of the knee, at or near the groin, at the arch of the aorta or the subclavian arteries, or at the flexure of the internal carotid, is suggestive when the relative infrequency of this condition in the artery running along the side of the

[1] See sections on variations of the arch of the aorta and the veins of the trunk.

[1] D. Stewart, Lancet, 1860, vol. 62.

shaft of a bone, as in the limbs, its rarity in the descending thoracic and abdominal aorta, and the almost absolute freedom from invasion seen in the common carotid are recalled. From the fact mentioned in the preceding paragraph, that an artery can be temporarily occluded in forced flexion, it would appear that a vessel so placed would be liable to compression or tension from varying states of the joint near which it is placed. Under favorable conditions this might lead to diseased action.—The vessels near a joint are frequently lacerated in dislocation.

Additional causes of diseased action are associated with undue constriction of the bloodvessels, or diminished elasticity of their walls. Narrowing of the lumen of the aorta will induce disease of the parenchyma of the kidney;[1] diminished elasticity of the walls leads to rupture and to the innumerable lesions arising from the escape of blood into the surrounding tissues.

Veins.—The veins receive the blood after it passes through the capillaries and conduct it to the heart. To assist the blood in its ascent, their walls are furnished, as a rule, with great numbers of valves. These valves are arranged in pairs, and consist of crescentic folds of the *tunica intima* (p. 73), so disposed as to present their free edges toward the larger or cardiac end of the vein. The valves are most numerous in the superficial veins of the extremities. They are absent in the smallest and the largest veins, in the sinuses, in all the veins in and about bones, the umbilical vein, the portal vein, the hepatic, renal, and uterine veins, and in the ovarian or spermatic vein. Dr. J. H. Brinton and Mr. Rivington, however, have demonstrated the presence of a valve at the junction of the right spermatic and the renal veins.

The veins are more numerous than the arteries. While the larger arteries, such as the carotid, the subclavian, the common iliac, the femoral, and the hypogastric, as well as the larger visceral trunks, have one accompanying vein, the majority of the arteries next in size have two veins connected by occasional transverse veins, the whole tending to form a coarse network whose longest segments are parallel with the artery. The superficial veins follow the course of the superficial nerves. In most instances where an artery and a vein are superimposed, the vein is the more superficial of the two. Hence veins are apt to be compressed by aneurismal tumors.—Veins exhibit a tendency to the formation of plexuses; as about the foramen magnum, the intervertebral canals, and in or about the bloodvessel glands.

[1] J. Zielonko, Virchow's Archiv., 1874, lxi. ii. 267.

The mechanical value of veins, by which term is meant the use of the vessels when full of blood, in their relations to adjacent structures, is very great. A viscus or other structure surrounded by a venous plexus, as a pelvic organ, or the cerebrum, is protected as by a cushion from shock or injurious contact, at the same time that the temperature is maintained.

The relation of venous trunks to neighboring parts is of value in studying their action after wounds or other lesions. The compression of the surrounding tissues by the escape of blood from a deep vein in the limb assists in arresting bleeding. Hence such venous hemorrhage is apt to be localized, and does not induce tension of the parts. Such compression would be less decided in the axilla and neck than in the thigh and forearm, while in the visceral cavities it would probably be entirely absent. The surrounding tissues can, however, in no wise arrest arterial hemorrhage. Thus if a large artery be wounded in its course through a limb, the collection of blood is large, and the general tumefaction great. Pollock[1] proposes by this fact to distinguish venous from arterial rupture.

The point where an artery divides or a vein receives a tributary is of interest. In the case of an artery an aneurism is liable to be located at the point where a twig is given off, and an embolus is apt to project into the lumen of a vein at the point where a venule is received.

Veins may be invaded by malignant disease. The internal jugular vein has become involved by a growth of soft cancer extending from the primary mass in the interior of the skull. In an instance recorded in connection with ligation of the common carotid, Lisfranc detected a tumor behind the angle of the jaw,[2] which proved to be of this character. Analogous processes occurring in the venæ cavæ, the femoral, and even in the azygos vein have been recorded.

THE HEART.

General Remarks.—The heart is a complex muscular apparatus designed for the propulsion of the blood. It is a symmetrical structure, and presents on either side of a common septum a pair of communicating cavities or chambers. The cavity which first receives the blood and sends it to the second is called the *auricle:* that which receives the blood from the auricle and sends it out of the heart is called the *ventricle.* The

[1] St. George's Hospital Rep., 1866, 247.

[2] Quoted by G. W. Norris, Am. Journ. Nat. Sci., 1874, 14.

opening of communication is called the *auriculo-ventricular orifice.*—The auricle and ventricle lying to the right of the septum receive venous blood from the body and send it by the pulmonary artery to the lungs; hence these portions are together termed the *right* or *venous heart.*—The auricle and ventricle to the left of the septum receive the oxygenized blood from the lungs and send it to the body by the aorta (fig. 2, Plate LVIII.), and the two together are spoken of as the *left* or *arterial heart.* The circulation of blood from the right ventricle to the left auricle is carried on by means of the pulmonary artery, the pulmonary capillaries, and the pulmonary veins, and is termed the *lesser* or *pulmonic circulation.* The circulation from the left ventricle to the right auricle, by means of the arteries and veins of the body, excepting those of the lungs, is called the *greater* or *systemic circulation.*

Each *auricle* is divided into its *sinus* or *body*, and the *auricular appendage;* the latter is a hollow projection of the wall forward, and is furnished with muscular fibres.

Each *ventricle* is divided into a *cavity* and a *conus*, the latter being the narrowed portion of the interior of the chamber placed between the semilunar valve and that segment of the auriculo-ventricular valve nearest the septum.

The interior of the auricles is smooth, except within the auricular appendages, where raised muscular bands called *musculi pectinati* are seen. The interior of the ventricle is much roughened by the raised fleshy bands called *columnæ carneæ.*

The Action of the Auricles and Ventricles.—The two auricles are receptacles of blood, and it is their function to send the fluid to the ventricles below. This requires but little force; in fact the blood *falls* into the ventricle by the diastole of that chamber, the weak muscular walls of the auricles exerting only a secondary and supplemental force thereto. The ventricles, on the other hand, are compelled to force blood over large surfaces against gravity through vessels of progressively narrowing diameters, and may be compared to a pair of pumps acting synchronously.

The Valves of the Heart and their Actions.—On each side of the heart the chambers are separated from one another by valves, as are the ventricles from the arteries passing from them. The former are called from their position the *auriculo-ventricular* valves, and the latter from their shape the *semilunar.*

The *semilunar valves* are simple in construction. Each valve consists of three crescentic membranous festoons, or segments, whose free borders are directed to the centre of the vessel, and whose fixed semicircular base-lines are continuous with the wall. Each festoon forms with the vessel-wall a cup, the base of which is fixed, and which is open above. In the centre of each segment is a small nodule called the *corpus Arantii.*—The arterial orifice is opened by the systolic current. When the festoons are thrown back, and are in contact with the vessel-wall, the cups are obliterated. The orifice is closed by the three cups becoming filled with the blood (the tendency of which is to flow back into the ventricle after having been driven thence by the systole) and being forced towards one another.

The *auriculo-ventricular valves* differ from the semilunar in having a continuous membranous ring or short tube surrounding the auriculo-ventricular orifice. From this ring a number of segments (two on the left, three to four in the right ventricle) hang vertically downward, which are controlled not only by the current of blood as in the case of the semilunar valve, but by the delicate muscles derived from the ventricular wall. These muscles are called the *Musculi Papillares*, and the slender tendons extending from them to the segments, the *chordæ tendineæ.* Both the muscles and their tendons are of varying size, and some of the *chordæ* appear to arise from the general muscular wall without union to any special muscular fasciculus or papilla.

The manner of the opening and closing of the auriculo-ventricular orifice by these valves differs from that of the semilunar valves, since the blood is not thrown into the ventricle as much as dropped in by the *active* downward withdrawal of the segments through the agency of the *Musculi Papillares* and their tendons. The closure of the orifice results, according to Onimus, from the vermicular contraction of the fibres of the ventricle moving up toward the base of the ventricle from the apex, and bringing in contact the down-drawn segments of the valve; or, according to Chauveau and Faivre, from the fact that the cone-like figure defined by the opposed sides of the valves is converted into a hollow piston or plunging cone, between the minute interstices of which the blood is unable to make a passage by which it may flow back into the auricle, and is consequently forced through the orifice of the pulmonary artery on the right side and of the aorta on the left.[1]

[1] This method of describing the action of the auriculo-ventricular valves originated with Parchappe in 1824, and has been accepted by many responsible teachers. For an extended account see Küss' Physiology.

The theory concerning the action of the auriculo-ventricular valves as just given differs from the one ordinarily taught, which may in contradistinction from it be called the theory of Valentine. This theory is given by Quain as follows: "During the contraction of the ventricles, the segments of the valves are applied to the openings leading from the auricles and prevent the blood from rushing back into those cavities. Being retained by the *chordæ tendineæ*, the expanded flaps of the valves resist the pressure of the blood, which would otherwise force them back through the auricular orifice; the papillary muscles, shortening as the cavity of the ventricle itself is contracted during its systole, are supposed thus to prevent the valves from yielding too much toward the auricle, which might have been the case had the *chordæ tendineæ* been longer, or fixed directly into the wall of the ventricle."

The theory of Parchappe is sustained by vivisection, while that of Valentine is based upon the analogy derived from the action of the semilunar valves.

The study of the heart will include the following heads:—

The Pericardium.
The Endocardium.
The Interior of the Heart.
The External Form and Position of the Heart.
The Structure of the Heart.
Development of the Heart and Great Vessels.
Malformations of the Heart and Irregularities of the Great Vessels.
Remarks.

THE PERICARDIUM.

The pericardium is a closed fibrous sac of a bluish-white color and lodged between the pleural sacs. As the name expresses, the pericardium surrounds the heart and incloses in part the vessels that arise from its base. It answers in general outline to the shape of the heart, and is fixed above to the great vessels, and below to the Diaphragm, while it is covered by the mediastinal pleura at the sides.

The pericardium extends from the level of the base of the ensiform cartilage to the middle of the manubrium, but lacks about eight lines of reaching the epi-sternal notch. Dr. J. B. Roberts[1] found the base to answer to a line drawn from a point just above the lower edge of the end of the sixth rib to the junction of the ensiform cartilage and the gladiolus. Transversely, at the level of the fourth intercostal space, it extends two inches and nine lines to the left of the median line, and to the right it extends two inches and three lines, and in consequence passes a shorter distance beyond the right margin of the sternum than the left. Sibson found the superficial surface or region of the pericardium to extend from the fourth to the sixth costal cartilage, and from the centre of the sternum to within one inch of the nipple.

The anterior wall of the sac is somewhat higher than the posterior, and reaches to the anterior wall of the aortic arch. The posterior wall reaches to the place of division of the pulmonary artery. In front the pericardium is in contact with the anterior mediastinum, behind with the structures within the posterior mediastinum.

The pericardium lies in direct apposition with the tendinous centre of the Diaphragm and a portion of the fibres of the left leaflet. To the former it is firmly and to the latter moderately adherent. When the Diaphragm descends, it stretches, lengthens, and widens the pericardium, according to Sibson, and thus lowers the heart, and, through the medium of the pericardium, exerts a direct strain upon the great vessels. Dr. W. Forbes[1] entertains the opinion that the Diaphragm does not descend in contraction, owing to the attachment existing between it and the pericardium, an attachment which is strengthened by lateral bands of fibrous tissue passing along the sides of the pericardium to the apex of the chest and thence to the cervical fascia.

The pleural sacs tend to cover the pericardium in front with the exception of a narrow slip extending along the left edge of the sternum.

The pericardium is composed of two layers, an outer, the fibrous layer (fibrous pericardium), and an inner layer (serous pericardium). The *outer layer* is a stout, resisting membrane. It is continuous above with the fibrous layer of the aorta, the superior cava, the pulmonary veins, and the divisions of the pulmonary artery. It can be also traced, as above stated, to the middle layer of the deep cervical fascia, and, according to some authorities, to the first rib by an expansion (costo-pericardial ligament) originally designed for covering the thymus gland. These attachments are described by Mr. John Wood[2] as constituting means by which the descent of the Diaphragm is prevented from exerting undue strain on the arch of the aorta, and thus indirectly aiding the aortic arch in maintaining its position.

[1] Paracentesis of the Pericardium, 1880, 42.

[1] Amer. Journ. Med. Sci., 1880, vol. 80, 88.

[2] Journ. of Anat. and Phys., iii. 8, 1868.

Teutleben,[1] previous to the observations of Forbes, described bands of fibrous tissue passing from the cervical fascia to the pericardium as suspensory ligaments of the last-named structure, which act in checking the descent of the tendinous centre of the Diaphragm.

The *inner* or *serous layer* of the pericardium is divided into a parietal and a visceral layer. The *parietal layer* lines the fibrous layer. It is not, however, continuous upon the fibrous covering of the bloodvessels, but passes at a point about one to one and a half inch from the base of the heart into the visceral layer. The *visceral layer* holds somewhat the same relation to the heart that the pulmonic pleura does to the lungs. It is closely adapted to the outline of the heart, and is so arranged over the great vessels as to embrace them in a common sheath.

The pericardium contains from half a drachm to half an ounce of a clear straw-colored fluid.

The arterial blood-supply is derived from the bronchial, the diaphragmatic, and the œsophageal arteries. The veins form three groups, two lateral, which join the superior diaphragmatic vein, and the middle, which is directed posteriorly to empty into the azygos vein. The nerves to the pericardium have been traced from the sympathetic and pneumogastric nerves.

J. Marshall[2] has described a fold of pericardium lying between the left pulmonary artery and the pulmonary vein, and extending thence to the left auricle, which contains a small vein (*vestigial vein*) thought to be the remains of the left vena cava of the fœtus.

Remarks.—The fact that the pericardium extends further to the left than to the right of the sternum enables the physician to puncture the sac by thrusting a trocar or aspirating needle through the fourth or fifth intercostal space at its median end,—namely, at a point two and a quarter inches from the median line of the sternum; or, as suggested by Larrey, through the space between the ensiform cartilage and the seventh costal cartilage.

The pericardium has been frequently wounded by knives and other implements. Intense acute pericarditis accompanied by paroxysms of dyspnœa is liable to ensue. For a case graphically described see A. Blaha.[3]

In distension of the pericardium the sac may reach a point as high as the first intercostal space, and as low as the epigastric region, where it may form a globular swelling visible beneath the integument. The lungs, especially the left division, will be displaced backward, and the liver and stomach downward. In extreme forms of distension the trachea at its bifurcation may even be pressed upon, and its lumen narrowed, while the heart is pushed upward. Friction sounds may be thus developed as high as the third, second, and even the first intercostal space.[1]

[1] Archiv. für Anat. und Physiol., 1877, 281, fig.
[2] Phil. Trans., part i., 1850, 133.
[3] Wien Med. Presse, July 16, 1877.

THE ENDOCARDIUM.

The endocardium is a thin serous membrane lining the interior of the heart. On the right side it is continuous with the venæ cavæ and the pulmonary artery, and on the left with the pulmonary veins and the aorta.

The endocardium intimately adheres to the heart, but has different degrees of thickness at its various parts. Thus it is thinner over the ventricles than over the auricles, and thinner over the right auricle than over the left. It is of extreme delicacy where it lies in contact with the *Musculi Pectinati* and the *columnæ carneæ*.

The endocardium is composed of two layers, an endothelial and a fibro-elastic layer. The endothelial layer is composed of pavement endothelium. The fibro-elastic layer is irregularly developed. It is best seen where the endocardium covers the valves of the heart. Elsewhere it intimately adheres to the muscular substance of the heart.

THE EXTERNAL FORM OF THE HEART.

The heart, described by its external features (figs. 3, 4, Plate LVIII., and figs 1, 2, Plate LIX.), is seen to be an inverted cone, whose base is directed upward and backward in the median line of the body, and whose apex lies at a point to the left of the median line. Its long axis is therefore placed between these two points. This statement is not strictly accurate, except as to the ventricular portion, since the axis of the auricles lies nearly in the longitudinal axis of the body.

The heart presents for examination an anterior and a posterior surface, a base, an apex, and an anterior and a posterior margin.

The *anterior surface* is convex, and looks upward. It is marked above and to the right by the right auricular appendage and the anterior border of the right auricle. The greater part of the anterior surface is composed of the right ventricle. To the left

[1] Sibson, Medical Anatomy.

border is seen a small portion only of the left ventricle. Between the right auricle and right ventricle is a transverse furrow, carrying the transverse portion of the coronary artery and vein and the lymphatic vessels; while between the right ventricle and the left ventricle is seen a longitudinal furrow carrying the longitudinal portion of the coronary artery and vein.

The *posterior* surface is nearly flat, looks downward, and lies in part upon the Diaphragm. It is marked by a transverse groove between the auricle and the ventricle for the transverse portion of the coronary artery, vein, and lymphatics; and near its right side by a longitudinal groove between the ventricles for the longitudinal portion of the coronary artery, vein, and lymphatics.

The *anterior* margin is thinner and longer than the posterior. It is composed entirely of the right ventricle and looks downward, forward, and to the right side.

The *posterior* margin is thick and obtuse; it is composed entirely of the left ventricle and looks toward the left side.

The *base* presents on either side the upper surfaces of the auricles. The pulmonary artery and the aorta are here seen, the former lying in front and to the left of the latter.

The presence of the well-defined groove between the auricles and ventricles has led to the adoption by anatomical writers of the phrase *transverse constriction*, or the *sulcus auriculo-ventricularum*. Lying between the ventricles in front and behind is a second groove which has received the name of the *longitudinal groove* or *sulcus*. These grooves, as applied to the entire figure of the heart, are confusing; for, while they are conspicuous features on the cardiac superficies, they have no exact value in reference to the heart as a whole. The transverse groove, for example, is absent in front of the origin of the pulmonary artery, and the longitudinal groove is absent both at the apex and at the base of the heart.

The heart should be considered as having its primary or true axis parallel to the venæ cavæ, which is the position maintained in quadrupeds. The long axis is, therefore, in such relations, parallel to the axis of the body. In man the heart is deflected to the left, in consequence of the flattened sternum. The peculiar half-twist forward of the ventricular portion, by which the anterior surface is made to look upward and the posterior surface downward, is, perhaps, due to the sagging of the heavy left ventricle while the base of the heart is fixed.

Size of heart.—The heart is five inches long, three and a half inches wide at its broadest part, and two and a half inches antero-posteriorly. The size of the heart has been commonly compared to that of the fist in the same individual. Its length is to its breadth as five is to four. Its weight is about eleven ounces. In the female the heart is about one-sixth less in weight and size than in the male.

The relative size of the orifices of the heart is a matter of importance to the physician. In early life those of the pulmonary artery and the aorta are of about the same size, but after the fortieth or fiftieth year the aortic orifice is the larger. Of the auriculo-ventricular orifices the right is somewhat the larger.

TOPOGRAPHICAL RULES FOR THE POSITION OF THE HEART.

(Figs. 1, 2, Plate LIX.; figs. 2, 3, Plate LXI.)

The heart lies in the middle mediastinum. Seen from in front it is directed obliquely downward and to the left. The auricles are nearly concealed in this view, since they lie more to the right side and behind. When seen from below, it is observed that the axis of both chambers is nearly vertical, that of the right lying directly to the right of the median line, while that of the left is at the median line. Behind the heart are the œsophagus and the aorta. In front of it lies the sternum, at the sides are the lungs.

The base lies opposite the sixth or seventh dorsal vertebra, the apex at about a thumb's breadth to the median side of the left nipple, at the fifth intercostal space. The anterior surface of the heart is almost entirely derived from the right auricle and ventricle. A small portion of the left ventricle forms the left border of the surface, the anterior edge of the left auricular appendage appearing at the border above. The apex is formed by the left ventricle in health, but in mitral regurgitation and pulmonary emphysema

EXPLANATION OF PLATE LVIII.

Fig. 1. General plan of the right side of the heart.

Fig. 2. General plan of the left side of the heart.

Fig. 3. General view of the heart and the great vessels arising from its base.

Fig. 4. The right side of the heart drawn in position—as seen in the supine body.

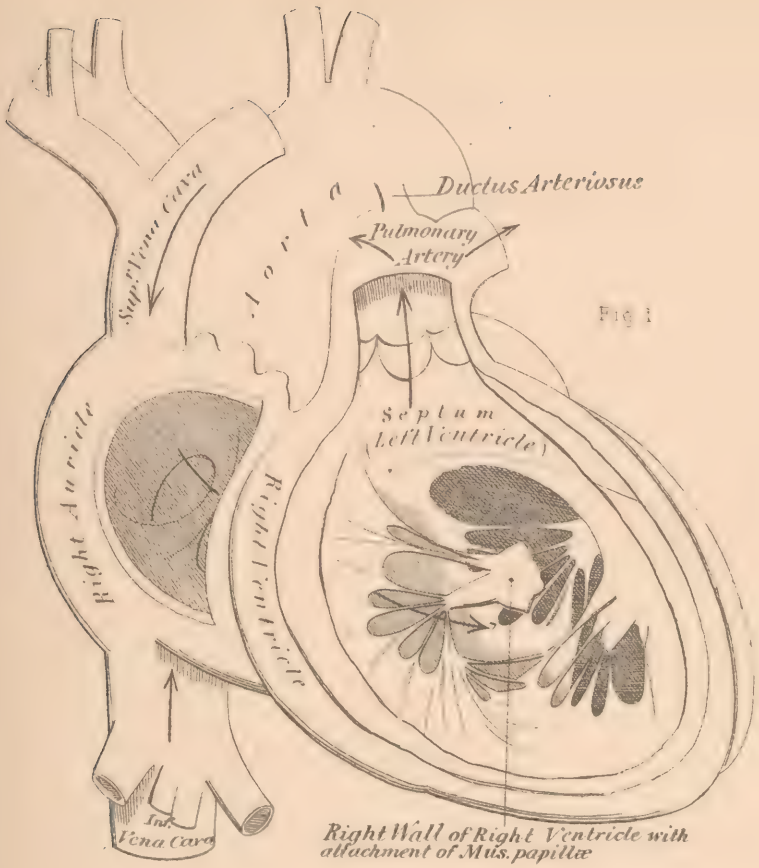


Fig 1

Right Wall of Right Ventricle with attachment of Mus. papillæ

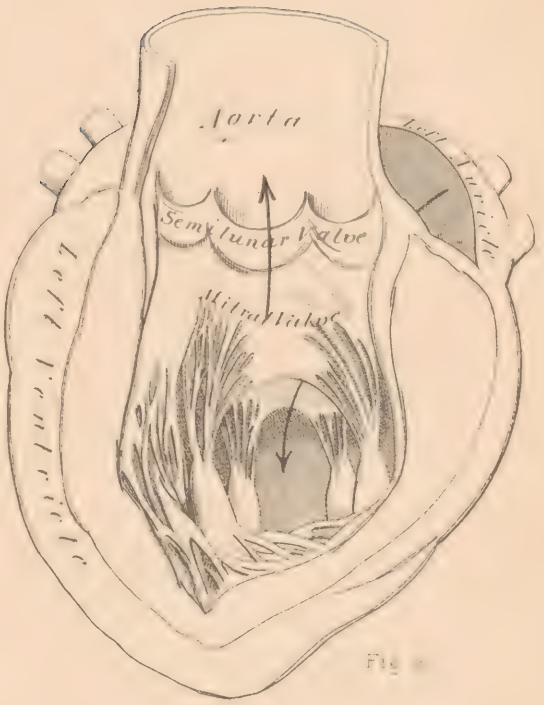


Fig 2

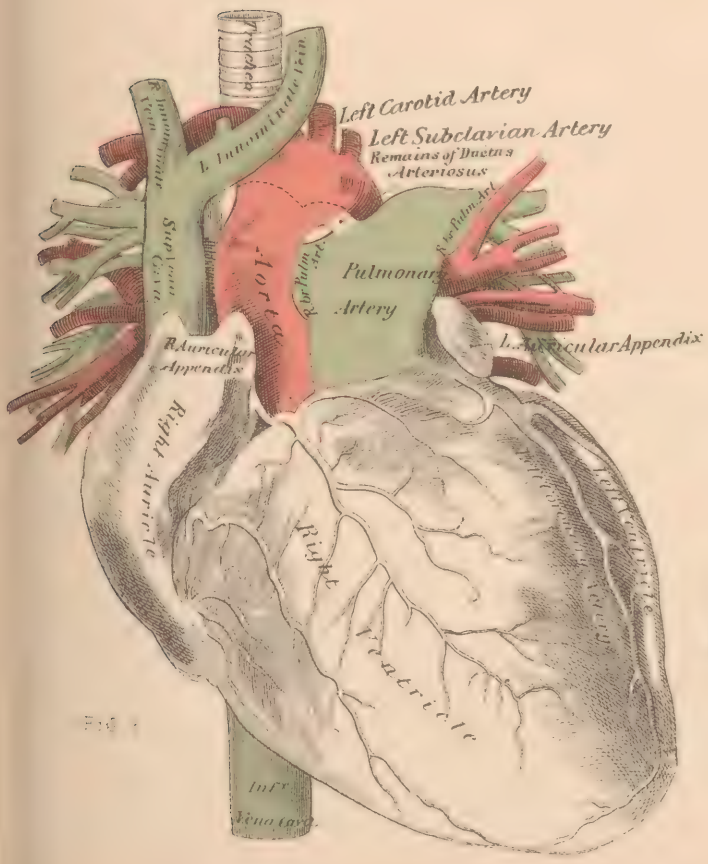


Fig 3

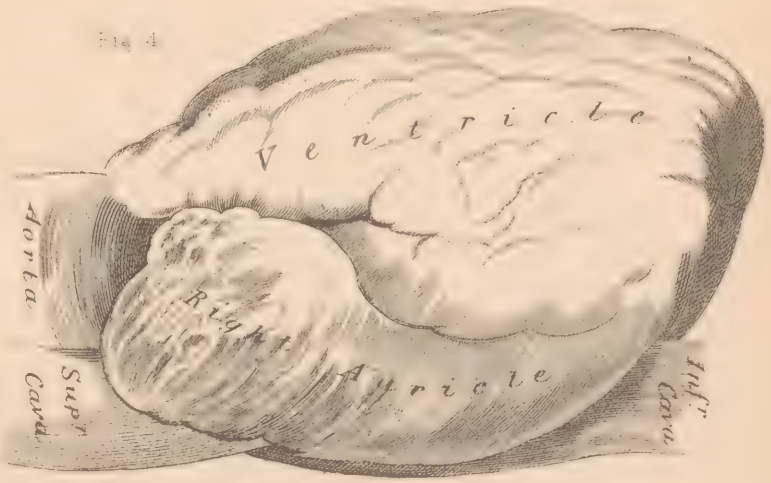


Fig 4

T. Sinclair & Son, Lith.

the right ventricle, according to Sibson, entirely covers the left.

Viewing the heart in its relations to the sternum, it is seen that the right auricular appendage and a small portion of the right auricle lie to the right of the sternum. The right third or half of the right ventricle, the right auriculo-ventricular valve, the median fourth or fifth of the conus pulmonalis and the pulmonary artery, with the origin of the aorta, lie directly behind the sternum. The remaining portion of the right ventricle, conus pulmonalis, and pulmonary artery lie to the left of the sternum.

The following rules, according to Sibson, mark the position of the several parts of the heart. The origins of the great vessels correspond to a line running across the sternum and along the lower edge of the second costal cartilage. In some subjects the vessels correspond with the line of the third cartilage.

The right auriculo-ventricular junction crosses obliquely from the left of the sternum above, to the right of it below.

The tricuspid valve is immediately to the left of the lower half of the sternum.—The semilunar valves lie on a line drawn through the centre of the third piece of the sternum, and passing midway between the third and the fourth costal cartilages, and thence behind to about the tip of the sixth dorsal spine.—The plane of the aortic orifice looks downward, *forward*, and toward the left. The plane of the pulmonary orifice looks downward, *backward*, and toward the left.[1] The pulmonary valves usually lie behind the second intercostal space.—The heart is in contact with the walls of the chest from the fourth to the sixth costal cartilage of the left side. This space is usually three inches from side to side, and two inches from above downward.

The superior surface of the heart in position is a small quadrilateral space, which measures three inches in diameter from right to left, and about two inches from above downward. It is bounded below by the Diaphragm, on the right and left by the lungs. The right side is flat, the left concave. The tongue-shaped lobe is pushed aside in systole, but returns in diastole.

It is a noticeable fact that the axis of the right side of the heart, passing from the auricle to the ventricle, is nearly horizontal, while that of the pulmonary conus is vertical. On the other hand, the axis of the left ventricle is nearly vertical, while that of the conus aorticus is also nearly vertical. It follows that the current of blood in the right side leaves the ventricle at nearly a right angle to its line of entrance, while the blood of the left side leaves the ventricle at a very acute angle to its line of entrance.

The posterior margin of the heart is partly lodged, with the intervention of the pericardium, in a depression of the left lung.

[1] John Wood, Journ. of Anat. and Phys., 1869, iii. 6.

A Detailed Account of the Heart.

The *right auricle* is the first chamber of the heart, since it receives the venous blood from the superior and inferior cavæ, and transmits it to the right ventricle.

The *exterior* is of an irregular cuboid form, and presents for examination four surfaces; an anterior, a posterior, a right or lateral (also called the external), and a left or median. The latter may be also named the septal surface, since it corresponds to the inter-auricular septum. The anterior surface of the auricle is convex, and, when the heart is in position, extends from the outer border of the sternum, about on a level with the upper border of the third rib, to the junction of the seventh rib with the sternum. At its anterior median part is placed the *auricular appendage*. This is of a triangular form, the base being at the auricular wall, and the apex nearly reaching the pulmonary artery. It is concave behind to accommodate itself to the anterior surface of the aorta, but convex in front.

The posterior surface is small and flat. The lateral surface is yet smaller than the posterior. It is limited by the space between the orifices of the venæ cavæ.

The *interior* of the auricle (fig. 1, Plate LX.) is marked as follows: above is the orifice of the superior vena cava. This, the smaller of the two great venous orifices, being placed slightly in front of the plane of the inferior cava, is directed downward and slightly forward and inward. Below is the orifice of the inferior cava, which is directed nearly horizontally forward and to the left. Between the two the auricular surface is slightly raised, and has received the name *tuberculum Loweri*. The anterior surface is marked with numerous vertical muscular ridges, arranged in the form of a coarse network, which have received the name of the pectinate fibres (*Musculi Pectinati*).

The base of the auricle presents the large oval auriculo-ventricular orifice, having a diameter of one and a fourth inch.—Extending from the inner margin of the orifice of the inferior vena cava is a sickle-shaped fold of the lining membrane, containing a few muscular fasciculi, called the *Eustachian valve*.

Between the auriculo-ventricular opening and the orifice of the inferior vena cava, but separated from the latter by the Eustachian valve, is a depression which receives the coronary vein. The depression is called *the coronary sinus*, and a valve at the orifice of the vein has received the name of the *valve of Thebesius*. Scattered over the auricle are depressions known as the *foramina of Thebesius*, several being found in the coronary sinus and several elsewhere on the lateral and anterior surfaces. Some of these have no special significance; others are the openings of small veins (*venæ minimæ cordis*).

The median (septal surface) is marked by a rounded flat depression, the *fossa ovalis*—the site of the embryonic *foramen ovale*—by means of which the blood entering the auricle by the inferior vena cava passed into the left auricle. The depression is guarded above and at the sides by a thickened fold, the *annulus ovalis*. The closure of the *foramen ovale* need not be so complete as to prevent the passage of blood from the right to the left auricle. Often, indeed, in hearts of individuals who have never been subject to the effects of such passage, small slit-like valvular openings have been detected after death in the upper part of the *fossa ovalis*.

The *right ventricle* is convex anteriorly, flat posteriorly, and slightly convex again within, at the median or septal side. Its walls are much thinner than those of the left ventricle, measuring but two-twelfths to three-twelfths of an inch in thickness.

The *interior* of the right ventricle (fig. 3, Plate LX.) is bounded behind and to the right by the tricuspid valve, and above and to the left by the semilunar valves of the pulmonary artery. The walls, where they come in contact with the leaflets of the tricuspid valve, and thence forward, are much roughened by raised, and in part free, interlacing muscular bands, the *columnæ carneæ* or *trabeculæ*, which unite to form a spongy cavernous network. Above, *i. e.*, between the region of the tricuspid valve and that of the semilunar valves, the walls are smoother, especially upon the septal side. The space embraced by the *columnæ carneæ* is the *true* ventricular cavity, as opposed to the narrowed ascending smooth portion, which is called the *infundibulum* or *conus arteriosus*.

The tricuspid valve, as the name expresses, is composed of three segments, which have received the conventional names of the anterior, posterior (right), and septal (left). The anterior segment is of a semicircular figure, the posterior of a sub-triangular figure, and the septal is triangular in form. The anterior and the posterior segments agree in possessing stout *chordæ tendineæ*, which are attached, for the most part, to their free edges, a few chordæ only passing to the mural surfaces. The septal segment is secured by delicate *chordæ*, which, far from being confined to the margin of the segment, extend from the entire septal surface to the septum. A greater degree of motion is thus allowed to the anterior and posterior segments than to the septal.—The papillary muscles controlling the segments vary in size. The anterior segment has a large muscle attached to the anterior wall of the ventricle, while the septal segment has two small, inconspicuous muscles. The posterior segment possesses a stout muscle, upon the anterior wall of the ventricle (near to and often united with the muscle of the anterior segment), and a second well-developed muscle in the angle between the anterior and the septal walls.

In addition, accessory segments are occasionally met with lying between the main divisions. Perhaps the most common of these is one lying between the posterior and septal segments. It partakes more of the character of the latter than of the former.

Mr. T. W. King[1] describes in detail the right ventricle of man, mammals, and birds, with the object in view of demonstrating a physiological arrangement of the tricuspid valve, which permits a distension of the ventricular cavity and regurgitation of blood to the auricle. He names the anterior and posterior walls of the ventricle the *yielding* walls, and the septal the *fixed* wall. Since the anterior and posterior segments of the valve secure attachment from the yielding walls, they are more mobile than the septal, and are more or less under the control of the muscular fibres in the yielding wall. They act efficiently in preventing regurgitation when the ventricle is moderately distended. When the ventricle is over-distended (as often occurs during transient states of pulmonic congestion), the segments are so dragged upon by the yielding walls as to prevent perfect closure of the auriculo-ventricular orifice.

[1] Guy's Hospital Reports, 1837, 104.

EXPLANATION OF PLATE LIX.

Fig. 1. The heart, seen in position from in front.

Fig. 2. The heart, seen in position from behind.

PLATE LIX

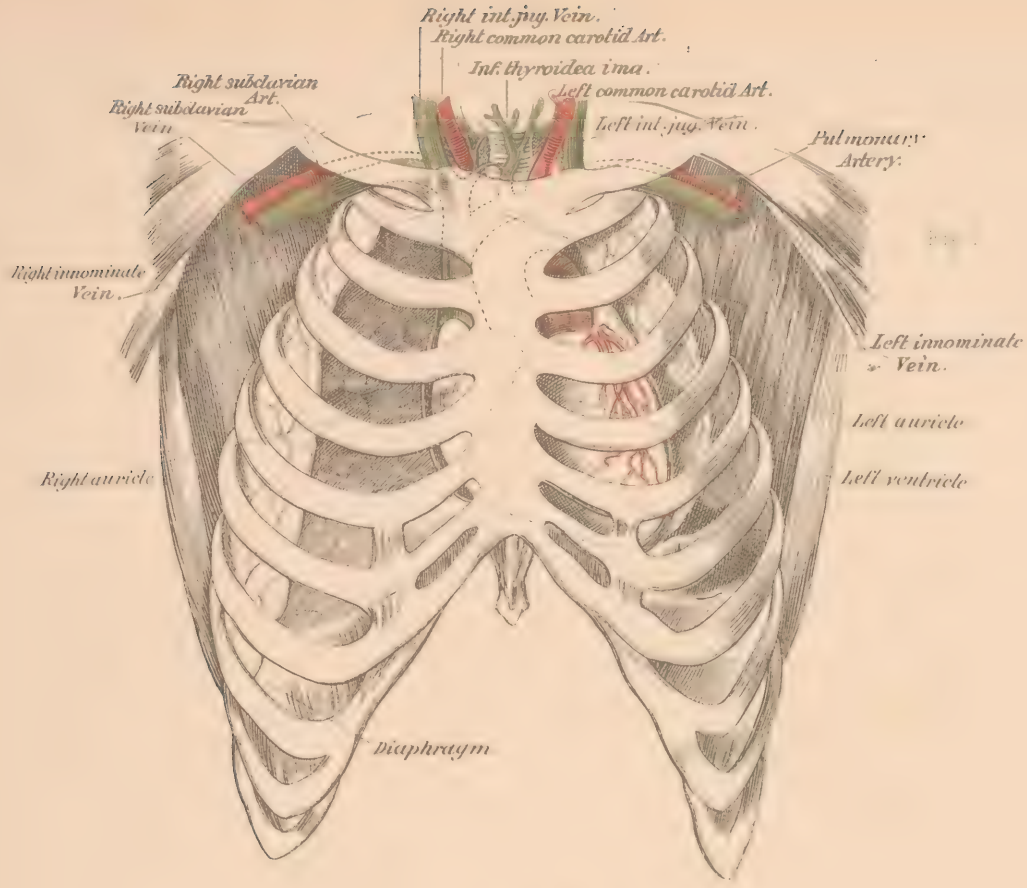


Fig 1.

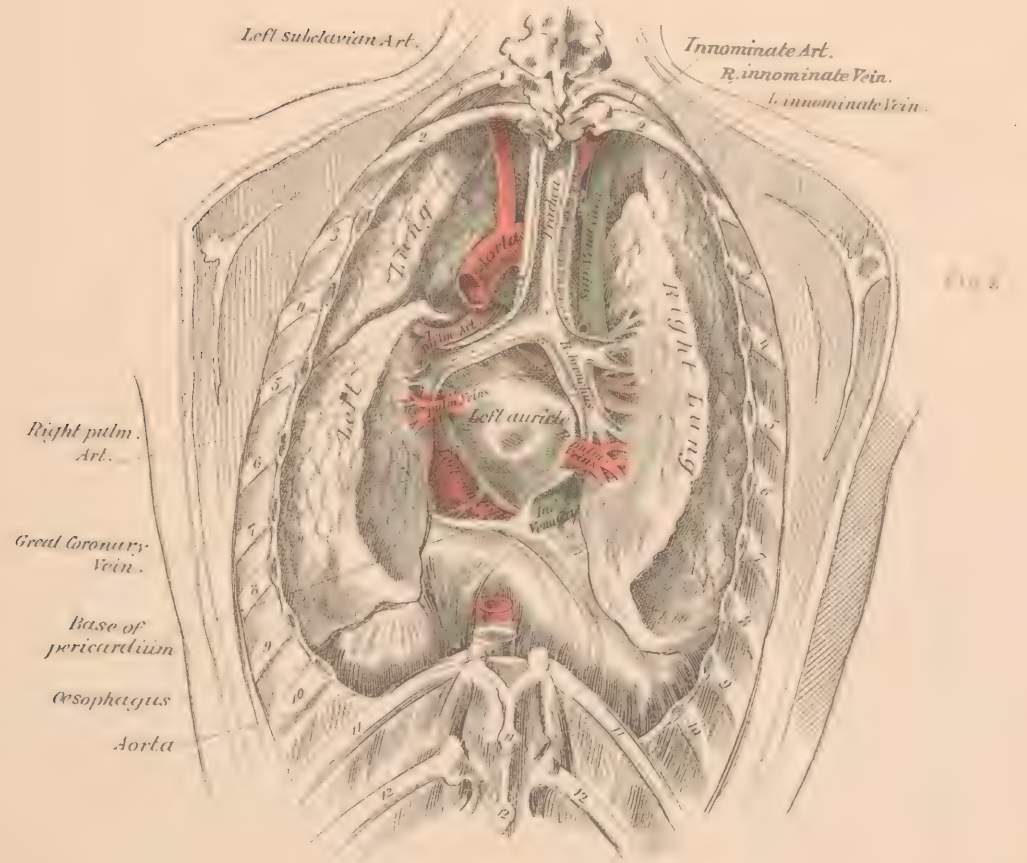


Fig 2.

T. Sinclair & Son, Lith.

In the same connection Mr. King calls attention to a muscular band, which stretches across the cavity between the two walls. This band may have an average length of six to seven lines, and a circumference of three or four; it is designed to limit the degree of ventricular distension, and is named the *moderator band*. It is especially well developed in the hearts of mammalian quadrupeds. An analogous structure of great strength exists in the hearts of birds.

The *left auricle* (fig. 4, Plate LX.) is of a cuboidal shape, and lies almost entirely at the posterior superior portion of the heart, a part of the auricular appendage alone being visible from in front. Its walls are slightly thicker than those of the right auricle, but its capacity is less than that of the right. The upper border is inclined backward and the lower border forward. Its anterior surface thus looks somewhat upward, and its posterior downward. Its form is slightly impressed by the pulmonary artery as well as by the aorta. Its posterior surface lies in front of the descending aorta and œsophagus. The auricular appendage is slightly twisted, somewhat constricted at the orifice, and emarginate at the sides. It rests against the pulmonary artery.

The *interior* of the auricle is made up of the main chamber or sinus and the auricular appendage. The former is smooth, free from pectinate fibres, and presents near its upper border the orifices of the pulmonary veins. The orifices of these vessels are arranged in approximated pairs on either side, the lower one being, as a rule, the larger.

The vessels of the left side may empty into a common depression or orifice prior to opening upon the auricle. Near this point is the orifice of the auricular appendage. The septal wall exhibits a faint raised edge, the remains of the annulus of the foramen ovale.

The *left ventricle* is situated more to the back of the heart than is the right. It is slightly longer than the right, so that the apex of the heart entirely pertains to the left side. While narrower than the right, the left ventricle is nearly three times as thick. Its general form is that of a pyramid. The base is directed upward and inward toward the median line of the body, the aorta actually arising a little to the right side of the septal line of the heart.

In the *interior* the *columnæ carneæ* (fig. 2, Plate LX.) are smaller but more numerous than in the right ventricle. The stout muscular papillæ are arranged in two groups; one anterior, the other posterior. The left auriculo-ventricular valve is named *bicuspid* as distinguished from the tricuspid. It is, however, very generally called the *mitral* valve. The two valves closely resemble each other, and closely conform to the type already seen in the anterior and posterior segments of the tricuspid valve.

The chordæ tendineæ are occasionally muscular, and may pass upward into the auriculo-ventricular valve. Muscular fibres, however, may be rarely found in the valve entirely apart from the preceding source.[1]

THE STRUCTURE OF THE HEART.

The heart exhibits an intricate arrangement of fibrous and muscular tissues. The fibrous tissue is found for the most part at the base of the organ. In the angle between the aortic and the two auriculo-ventricular openings is found a small fibrous mass. This may be fibro-cartilaginous, and in some animals is bony. From this region processes of fibrous tissue extend backward between the two auriculo-ventricular orifices beneath the inter-auricular septum. Others pass forward, one on each side of the opening of the aorta.

The muscular tissue of the ventricles exists chiefly in the form of layers which are more or less perfectly defined, and are arranged in an exceedingly intricate manner. Following Pettigrew, the layers of the ventricle are seven in number. They are so arranged that the first three, counting from without inward, are oblique. The fourth is transverse, while the remaining three are again oblique, but pursue a course the opposite of that seen in the outer three.

Pettigrew uses the following language with respect to the details of the above arrangement:—

There is a gradational sequence in the direction of the fibres constituting the layers, whereby they are made gradually to change their course from a nearly vertical direction to a horizontal or transverse one, and from the transverse direction back again to a nearly vertical one. Thus, in dissecting the ventricles from without inwards, the fibres of the first layer, which run in a spiral direction from left to right downward, are more vertical than those of the second layer, the second than those of the third, the third than those of the fourth—the fibres of the fourth layer having a *transverse* direction, and running at nearly right angles to those of the first layer. Passing the fourth layer, which occupies a central position in the ventricular walls, and forms the boundary between the external and internal layers, the order of arrangement is reversed, and the fibres of the remaining layers, viz., fifth, sixth, and seventh, gradually return in an opposite direction, and in an inverse order, to the same relation to the vertical as that maintained by the fibres of the first external layer. This remarkable change in the direction of the fibres constituting the several external and

[1] John W. Ogle, Trans. Path. Soc. of London, ix., 1858, 116.

internal layers, which is observed to occur in all parts of the ventricular walls, whether they be viewed anteriorly, posteriorly, or from the septal side, has been partially figured by Senac,[1] and imperfectly described by Reid,[2] but has not hitherto been fully elucidated. It has not had that share of attention bestowed upon it which its importance demands.

The two sets of fibres which constitute the superficial or first external layer of the left ventricle, and which enter the left apex in two separate portions or bundles, are for the most part continuous in the interior with the *Musculi Papillares*, to the free ends of which the chordæ tendineæ are attached. The *Musculi Papillares*, as will be seen from this account, bear an important relation to the segments of the mitral valve, to which they are directly connected by tendinous bands. They merit from this circumstance a more particular description than that given of the other fibres.

On looking at the left auriculo-ventricular opening, the *fibres of the first layer* are seen to arise from the fibrous ring surrounding the aorta, and from the auriculo-ventricular tendinous ring in two divisions: the one division proceeding *from the anterior portions of the rings*, and winding in a spiral, nearly vertical, direction, from before backward, to converge and enter the apex *posteriorly;* the other set proceeding *from the posterior portions of the rings*, and winding in a spiral direction from behind forward, to converge and enter the apex *anteriorly*. Having entered the apex, the two sets of external fibres are collected together, and form the Musculi Papillares and columnæ carneæ; the one set, viz., that which proceeded from the auriculo-ventricular orifice *anteriorly* and entered the apex *posteriorly*, curving round in a spiral direction from right to left upward, and forming *the anterior Musculus Papillaris and the columnæ carneæ next to it;* the other set, which proceeded from the auriculo-ventricular orifice posteriorly, and entered the apex anteriorly, curving round in a corresponding spiral direction, and forming *the posterior Musculus Papillaris and adjoining columnæ carneæ*. As the external fibres converge on nearing the apex, so the internal continuations of these fibres radiate toward the base; and hence the conical shape of the Musculi Papillares. Particular attention is directed to the course and position of these structures, as they have always, though erroneously, been regarded as simply vertical columns, instead of more or less vertical *spiral columns*. It is worthy of remark that, while the left apex is closed by two sets of spiral fibres, the left auriculo-ventricular orifice is occluded during the systole by the two spiral flaps or segments constituting the bicuspid valve. The bilateral arrangement, therefore, which obtains in all parts of the left ventricle and in the *Musculi Papillares* extends also to the segments of the bicuspid valve, and hence its name. What has been said of the arrangement of the fibres in the left ventricle applies with slight modifications to the fibres of the right one; and many are of the opinion that the tricuspid valve is in reality bicuspid in its nature. The shape of the ventricular cavities of the heart of the mammal greatly influences the movements of the mitral and tricuspid valves, by *moulding the blood into certain forms*, and causing it to act in certain directions. A precise outline of the ventricular cavities is obtained by filling the ventricles with wax or plaster of Paris, these substances, when allowed to harden, furnishing an accurate cast of the parts.

[1] Traité de la Structure du Cœur, de son Action, etc. Paris, 1749.

[2] Cyc. of Anat. and Phys., art. "Heart." London, 1839.

The Development of the Heart and the Great Vessels.

The heart at the third week is tubular, bent upon itself, and the auricular or *lower* portion receiving the omphalo-mesenteric vein is placed above or behind and to the left of the ventricular part. Above the ventricular part is a cone-shaped chamber, continuous above with the vascular arches, which is called the truncus communis arteriosus or aortic bulb.

In the sixth or seventh week the septum of the ventricle makes its appearance. In the eighth week the auricular septum is begun. At about the same time, three veins enter the auricle from behind. Of these, two correspond to the right superior cava and the inferior cava, and the third to the left superior cava of the adult. They are connected with what afterward becomes the coronary sinus.

In the eleventh week the Eustachian valve forms, beginning from above, and advancing toward the base of the heart. In the seventh week the division of the bulb into aorta and pulmonary artery begins. This affects the inner and middle layers of the bulb only.

The development of the valves is coincident in time with the appearance of the septa. A. C. Bernays[1] has elaborately described and figured the development of the auriculo-ventricular valves. He found the

[1] Morpholog. Jahrbucher, 1876, Bd. ii. 478.

EXPLANATION OF PLATE LX.

Fig. 1. The view of the interior of the right auricle.
Fig. 2. The view of the interior of the left ventricle.
Fig. 3. The view of the interior of the right ventricle.
Fig. 4. The view of the interior of the left auricle.

Fig. 1

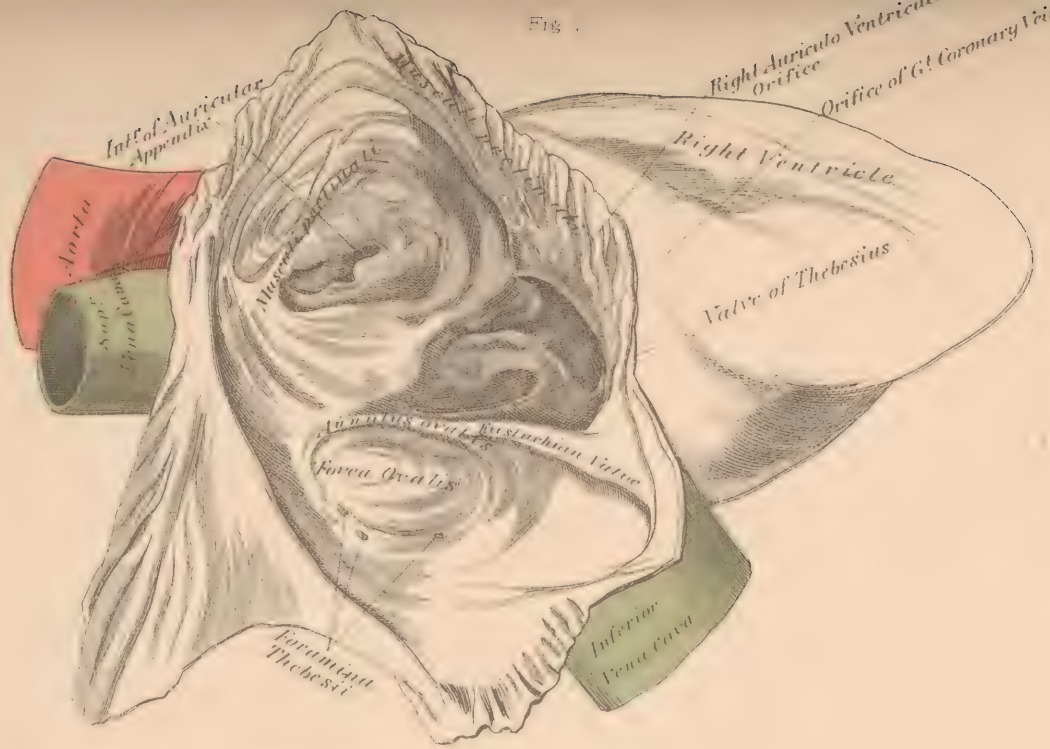


Fig. 2

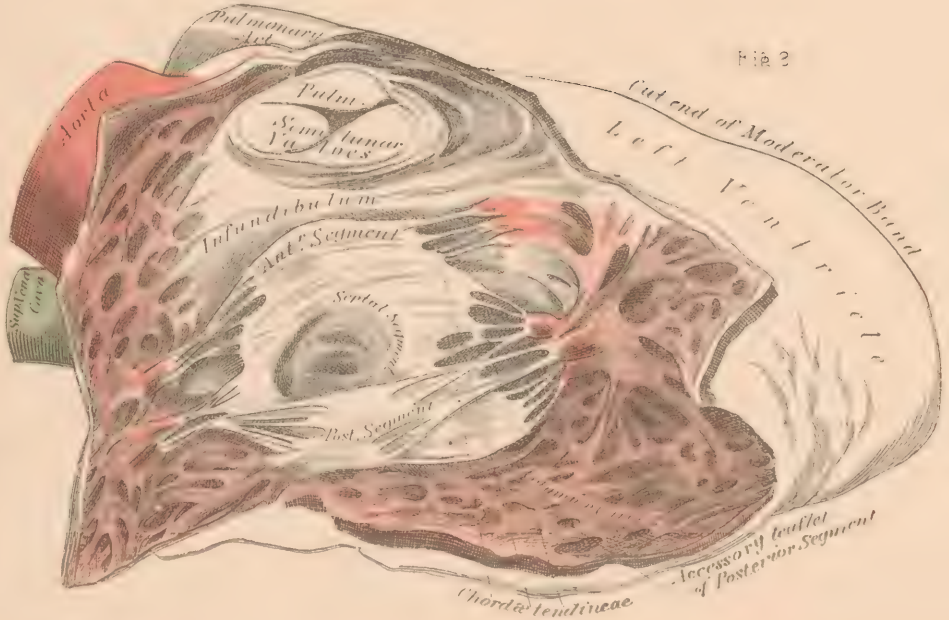


Fig. 3

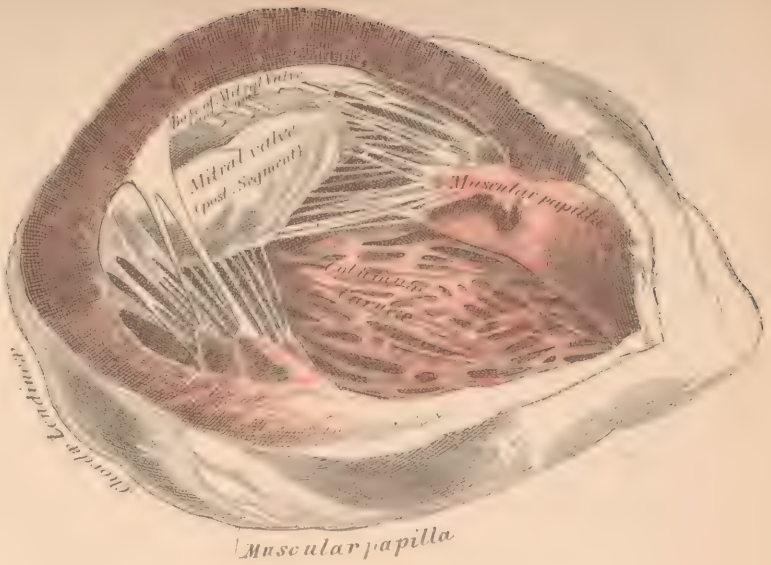


Fig. 4.

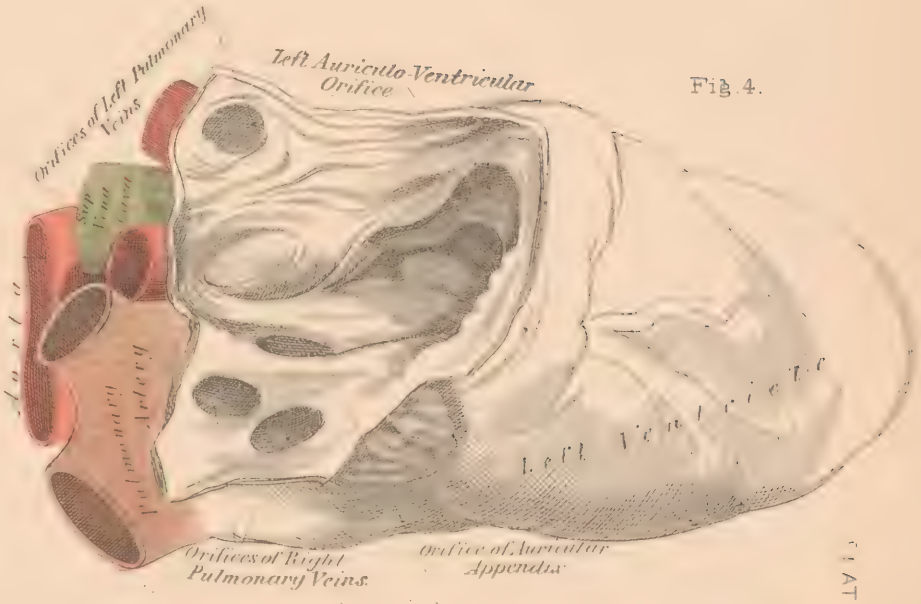


PLATE LX

segments and the *chordæ tendineæ* of each valve to arise from the inner layer of the wall of the ventricle, and to contain muscular fibres in common with those of the papillary muscles to which they were attached. This description is in harmony with the account of the action of these valves given on p. 339, and accounts for the occasional presence in the adult of muscular fibres in the segments of the valves,[1] as well as for the anomaly of the direct insertion of *Musculi Papillares* upon the segments, instead of the normal indirect insertion through the medium of the *chordæ*. —The semilunar valves appear to be developed from the endothelium.

The development of the great vessels as they arise from the base of the heart occurs in a definite order, in the description of which the language of Prof. Turner, in his epitome of Rathks' researches on the subject, will be employed (fig. 4, Plate LXII.).

"At an early period of embryonic life," says this writer, "the vascular system consists of the following parts: a short trunk, proceeding from the heart (*truncus communis arteriosus*); of two longer trunks situated in the visceral chamber, under the vertebral column, which run parallel to each other, and subsequently converge, so as to coalesce and form a single vessel (*trunk of the aorta*). Passing between the truncus communis and the trunk of the aorta, on each side is a series of arch-shaped vessels (*vascular arches*), which are situated in the wall of the visceral chamber. These arches consist of five pairs, though it is very doubtful whether they all exist at the same time. It is by the junction of these different arches with each other, under the vertebral column, that the parallel vessels are formed which subsequently unite to form the trunk of the aorta. The trunk of the aorta is thus to be regarded as a secondary vessel, for which the parallel trunks serve as two special roots (*primitive aortic roots*). The mode of development from this simpler typical arrangement into the condition met with in the fully formed animal is due to metamorphoses taking place in these vessels in certain given directions. Some of the changes are progressive, and produce an increase in the size and importance of certain of the vascular arches, and the trunks to and from which they proceed. Others, again, are retrogressive; the development and growth of the vessels is either not commensurate with the development and growth of the individual, or atrophy, to a greater or less extent, takes place, so that portions of them disappear."

A scheme, such as is embraced in this account, will be employed in the next section in describing the most striking irregularities of the large vessels.

[1] See p. 345.

MALFORMATIONS OF THE HEART AND IRREGULARITIES OF THE GREAT VESSELS.

The following epitome of this difficult subject is abridged mainly from the elaborate writings of Prof. Wm. Turner,[1] Dr. T. B. Peacock,[2] and Dr. Norman Chevers.[3] The language of the first-named author has been largely retained. For further information the student is referred to these memoirs. A. Sabbatier[4] and W. Krause[5] may also be consulted.

MALFORMATIONS OF THE HEART.

Fourteen types of malformation of the heart have been described. A brief account of these is here given, together with the analogues from the lower animals which most nearly approach them in character.

Heart consisting of a single auricle and ventricle, together with the ductus communis arteriosus.—The single vessel is mainly aortic, a pulmonary branch being evident. Two pulmonary veins empty into the descending vena cava or auricle. It is caused by arrest of development at a period prior to the appearance of septa.

This type is the analogue of the piscine heart, from which it differs in the absence of multiple valves in the truncus. The vascular arches are in such cases appropriated in a normal manner, hence the return blood from the aerating organ cannot empty into the aorta as in the fish, but must enter the single auricle or the descending vena cava.

Heart with permanent foramen ovale.—This malformation is caused by contraction or obliteration of the pulmonic orifice after the completion of the ventricular septum. The blood from the superior cava, not being transmitted through the right side of the heart, regurgitates into the right auricle, and is deflected through the foramen ovale, which is thus prevented from closing.

Analogue.—The heart of the seal, which, however, does not possess a contracted pulmonary artery.

Heart having a patulous ductus arteriosus with imperfect ventricular septum.—This deformity is the result of the contraction either of the pulmonary artery, or of the right auriculo-ventricular orifice, occurring at a period before the completion of the

[1] Brit. and For. Med.-Chir. Rev., 1862, 173. 461.
[2] Malformations of the Heart, London, 2d ed. 1866.
[3] London Med. Gaz., 1846–1848.
[4] Annal. des Sciences Nat., xix., 1874, 31.
[5] Henle's Anatomie, iii., 1st ab. 203.

ventricular septum. It may also be due to a contraction of the left auriculo-ventricular orifice, which results in the blood being forced to the right of the imperfect septum, and thus tending to prevent closure of the septum and the ductus arteriosus.

Analogues.—The heart of the turtle, which has no ventricular septum and a permanent ductus arteriosus. The heart of the serpent, which has an imperfect ventricular septum and a permanent ductus.

The contraction of the pulmonary artery at an early period of intra-uterine life *may* produce sufficient obstruction to prevent the complete development of the ventricular septum.[1] The septum in such cases is present. Therefore, in a tricœlian heart (*i. e.*, one possessing three chambers), the pulmonary artery is not apt to be obstructed. That the contraction is not the sole cause of septal insufficiency is shown by numerous examples.

Even in the normal adult heart, a small space measuring seven lines in width, which corresponds to the position of the inter-ventricular opening of fœtal life, can be defined at the basal portion of the inter-ventricular septum, at which the two ventricles are separated only by the endocardium and fibrous tissue. It is probable that the septal leaflet of the tricuspid valve protects this space, and guards the inter-ventricular opening when present. The space is closed at birth, though it may rarely open under the influence of disease.[2] It may also form the base of a diverticulum directed within the left ventricle.

When, with the permanence of the ductus arteriosus an incomplete ventricular septum is associated, some serious impediment to the circulation, existing either before or after birth, and which ceased to operate as age advanced, or remained undetected after death, may be inferred.[3]

Heart with a patulous ductus arteriosus and foramen ovale, with an imperfect ventricular septum.—This is due to the same general causes as the foregoing; the contraction occurring in the pulmonary artery beyond the origin of the ductus arteriosus, or the contraction being located in the mitral valve. The blood in the latter instance is forced through the foramen ovale into the right auricle, and thence into the left auricle, preventing closure of the ventricular septum and the ductus.

Heart with truncus communis imperfectly divided into aorta and pulmonary artery.—This is usually a more or less successful attempt at the formation of an auricular septum and of auricular appendages.

[1] N. Chevers, London Med. Gaz., iii. N. S. 1846, 703.
[2] Peacock, loc. cit. 29. [3] Chevers, loc. cit. 1087.

Heart with truncus communis completely divided, but the vascular arch abnormally united thereto.—In these cases the fifth vascular arch meets the aortic (systemic) stem, and the fourth the pulmonary. The aorta arises, therefore, in such cases from the *front* of the right ventricle, while the pulmonary artery arises from the *back* of the left ventricle. With this transposition the ventricular septum is often defective.

Heart with incomplete ventricular septum inclined to the left, and the aorta communicating with both ventricles.—This malformation is due to obstruction in the flow of the blood in the right side of the heart, and its deflection to the left side through an imperfect ventricular septum. According to Peacock,[1] in some cases the retention of the aorta in connection with the right ventricle is an example of arrest of development by which the earlier position of the vessel is retained.

Heart with an imperfectly defined ventricular septum, and tendency to separation of the right ventricle from the infundibulum.—Etiology. Arrest of development of the ventricular septum, with exaggeration of the ventricular limit of the infundibulum. Peacock[2] describes this malformation as an apparent reduplication of the right ventricle.

Analogue.—Heart of turtle, in which the above conditions are constant.

The foramen ovale prematurely closed, with the result of enormous enlargement of the right and diminution of the left side of the heart.

The ductus arteriosus prematurely closed, with the result of restricting the flow of the blood of the right side of the heart to the lungs.

The heart may rarely present a double apex. Etiology.—Retraction of the line of the ventricular septum. Analogue.—Heart in the dugong.

Heart with the foramen ovale and ductus arteriosus both open.

Heart with the foramen ovale open, but the ductus arteriosus closed.—This malformation is commonly associated with constriction of the mouth of the aorta.

A. T. Thompson describes a case (Med.-Chir. Trans. xxv. 247) in which a septum existed between the infundibulum and the body of the right ventricle. "One of the divisions" of the tricuspid valve was employed in partially covering the communicating opening between the divisions of the right ventricle.

Heart with ductus arteriosus arising from the right ventricle. The following is the probable solution of this malformation: Cleavage of the truncus communis in such wise that three instead of two trunks

[1] Loc. cit. p. 43. [2] Loc. cit. p. 76.

are seen; one of these joins the fourth vascular arch and becomes aortic, a second joins the fifth and becomes pulmonic, the third joins the fourth vascular arch and becomes the ductus arteriosus.

Analogue.—Reptilian heart, in which the cleavage of the truncus communis into three parts is constant; two of these join the right and left aortic fourth vascular arches; the third joins the fifth.[1]

The heart may retain its primitive position near the head. Thus it has been found united to the tongue between the ununited halves of the lower jaw. The high position of the heart is a piscine characteristic.

The heart, in defective formation of the Diaphragm, may be lodged in the abdomen, where it rests upon the liver, in which position it recalls the normal relation exhibited in reptiles.

IRREGULARITIES IN THE AORTA, PULMONARY ARTERY, AND SUBCLAVIAN ARTERIES.

The irregularities of the great vessels conform to the following types. They are fifteen in number, and may be briefly described as follows:—

Persistence of the fourth pair of vascular arches, and of both aortic roots (fig. 1, Plate LXII.).—Three or four cases of this malformation have been recorded. The aorta arches to both sides, the union of the right and left arches forming the descending aorta. In these cases the anterior of the two divisions is the true left aorta; for it is situated in front of the trachea and œsophagus, and from it the left carotid and subclavian arteries arise.

Analogue.—Reptilian type, particularly the variety seen in turtles.

Persistence of both aortic roots, and of the fourth right vascular arch. Entire or partial atrophy of the fourth left arch.—In these varieties the left subclavian artery arises low down, and represents the left aortic root, and passes between the œsophagus and the spine. Since the left ductus arteriosus is connected with the left fourth vascular arch, it is found that this canal is liable to be modified. It is either patulous, atrophied, or absent. The innominate artery is also absent. Such a fœtus would in all probability have a right ductus arteriosus extending between the fourth and fifth vascular arches. When the atrophy of the left arch is partial, a left innominate artery is present, the left subclavian of course arising from it.

[1] This case is reported by Wrisberg (Göttingensche Anzeigen, 1778). It is rejected by Turner (loc. cit.) as being imperfectly recorded. Since its explanation coincides with that of the reptilian heart it has been retained as above.

Atrophy of the fourth left vascular arch between the origins of the common carotid and subclavian arteries. Persistence of fifth left arch and aortic root (fig. 5, Plate LXII.).—In such rare instances the ascending and descending aortæ are detached, while the left subclavian arises from the lower aortic trunk. The descending aorta receives its blood through the pulmonary artery and patulous ductus arteriosus.

Atrophy of the fourth left vascular arch beyond the origin of the left subclavian. Persistence of the fifth left arch and left aortic root (fig. 2, Plate LXII.).—The aorta ascends and turns to the left so as to form its arch, from which the right innominate, left carotid, and subclavian arteries arise. Below the origin of the left subclavian the aorta is contracted, the exact position of the contraction varying in different instances. The left aortic root thus forms a "pouch-like" projection from the aortic stem. The ductus arteriosus retains its fœtal proportions, or may contract to a fibrous cord. In the rare event of the left arch being entirely disassociated with the descending aorta, the ductus arteriosus remains patulous, and supplies the preceding vessel from the pulmonary artery, as shown in the preceding section.

Transference of the left subclavian artery at its origin from the fourth to the fifth vascular arch.—The fourth vascular arch is here perfect, but the left subclavian does not arise from it, but appears to be derived from the ductus arteriosus. The blood from the pulmonary artery and the ascending aorta enters the ductus arteriosus, and passes thence to the left subclavian artery.

Atrophy of the fourth right vascular arch, but persistence of the right aortic root (fig. 3, Plate LXII.).—The right subclavian ordinarily arises from the junction of the transverse with the descending thoracic aorta. It passes obliquely upward and to the right, in front of the bodies of the upper dorsal vertebræ, and behind the trachea and œsophagus (very rarely between these tubes) to the root of the neck on the right side. The innominate is of course absent, the right carotid arising separately from the arch.

Persistence of the fifth pair of vascular arches.—A single instance is recorded in which the pulmonary artery terminated in part in the right subclavian artery close to its origin from the innominate.

Atrophy of the fifth pair of vascular arches.—Obliteration of the ductus arteriosus is often due to constriction of the pulmonary orifice.

Persistence of the primitive aortic septum.—The two primitive aortæ may not entirely coalesce, leaving a longitudinal septum between the two halves.

Rarely the aorta presents a septum dividing it

internally into two canals, without, however, any external evidences thereof.

The presence of the aortic septum is not susceptible of a simple explanation. Its existence at the beginning of the aorta is indicative of imperfect *division* of the truncus communis, by which the formation of the *second* aorta of the chelonian type has been hinted at, but not accomplished. Its existence in the descending aorta is indicative of imperfect *coalescence* between the two primitive aortæ.

Approximation and coalescence of the innominate and left carotid arteries. Etiology.—Approximation and junction of these arteries are due to the vessel (third left ventral communicating) which connects the third and fourth left vascular arches. This vessel is ultimately developed into the left common carotid artery, which arises so near to the commencement of the fourth left arch that by a slight shortening of the arch it becomes continuous with the fourth right arch.

Analogues.—In apes, many rodents, and carnivora.

Approximation and coalescence of the innominate, left carotid, and subclavian arteries. Etiology.—All the branches of the arch arise by a single trunk, which may be called the anterior aorta. No proper arch is formed by the aorta.

Analogues.—The division of the aorta into two parts without the formation of a definite arch is the normal disposition in the horse and ruminants.

Approximation and coalescence of the left carotid and subclavian arteries. Etiology.—We have seen that the absence or imperfect development of the fourth left vascular arch may lead to the union of the left subclavian and the left carotid arteries. It may also occur in persistence of both aortic arches.

Analogues.—In bats, some of the cetacea, and birds.

Separation of the innominate into the right carotid and subclavian arteries. Etiology.—Shortening of the fourth right arch, by means of which both the right carotid and subclavian are brought into contact with the fourth left vascular arch so as to arise from it.

The origin of the right subclavian from the right aortic root has been explained above.

Analogue.—This disposition is normal in the walrus.

Separation of the innominate into the right carotid and subclavian; approximation, and coalescence of the right and left common carotid arteries. Etiology.—The shortening of the fourth vascular arteries at their commencement would lead to the coalescence of the two vessels.

Analogue.—This disposition is normal in the elephant.

Separation of the innominate into the right subclavian, and through atrophy of the right common carotid, into the right external and internal carotid arteries. Etiology.—Shortening or absence of the third ventral communicating artery.

Analogue.—In some cetacea, as the dolphin, the internal and external carotids arise from the innominate artery.

The great importance of a knowledge of the mechanism of the heart, as studied in connection with the etiology and symptomatology of its diseases, has been so thoroughly appreciated by the profession that there would appear to be no need of epitomizing so important and yet so difficult a subject in this connection. The reader is referred to any of the manuals of the heart and its diseases, or to the chapters on physical diagnosis of the diseases of the heart in works on the practice of medicine.

PULMONARY ARTERY AND VEINS.

THE PULMONARY ARTERY.

The pulmonary artery (figs. 1 and 3, Plate LVIII.; figs. 1 and 2, Plate LIX.; figs. 3 and 4, Plate LX.; fig. 2, Plate LXI.) arises from the front part of the right ventricle, from which it is separated during the ventricular systole by the semilunar valves. The trunk passes upward and slightly to the left, in front of the origin of the aorta. Its length is from one and a half to two inches. Its circumference above the semilunar valves is two inches and eight and a half lines, and at the point of junction between the infundibulum and the semilunar valves three inches and two and a quarter lines.[1]

The vessel lies at its origin behind the second inter-

[1] N. Chevers, Lond. Med. Gaz., 1846, 191.

EXPLANATION OF PLATE LXI.

Fig. 1. The aorta and its branches.

Fig. 2. The heart and great vessels, seen in position from the left side.

Fig. 3. The heart and great vessels, seen in position from the right side.

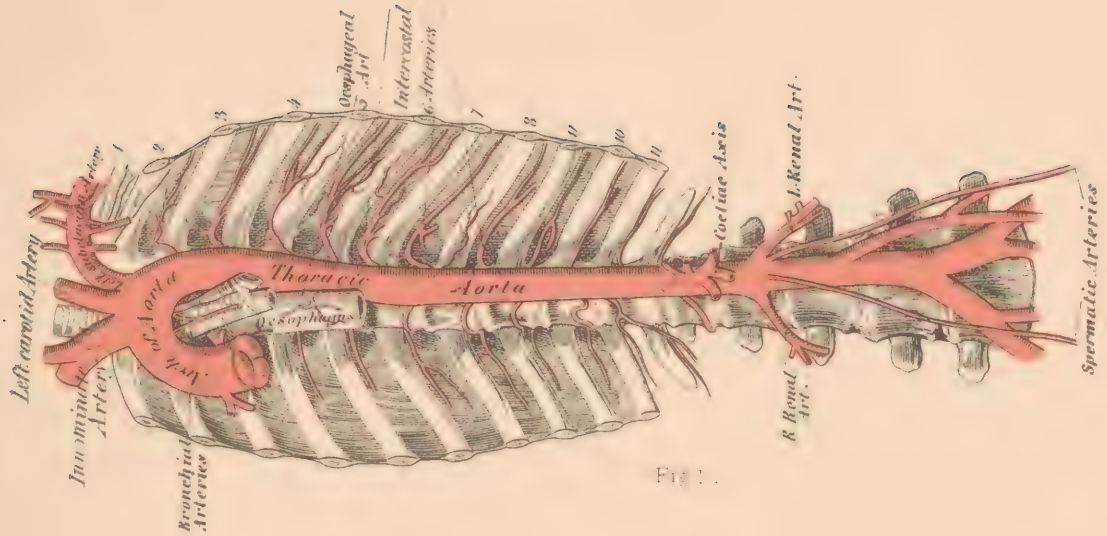


Fig 1.

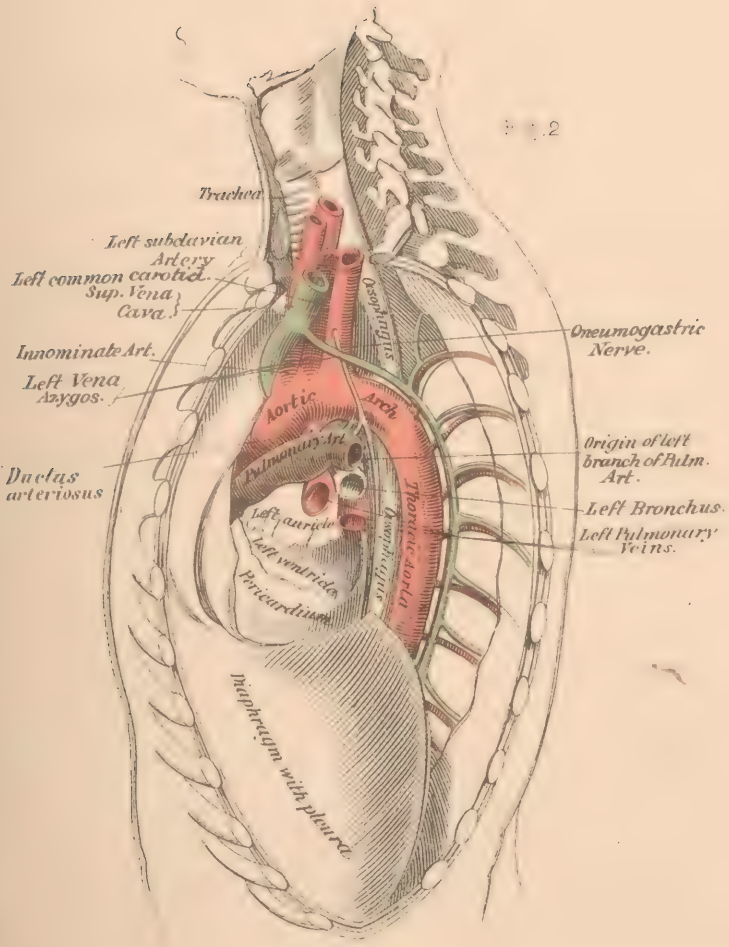


Fig 2.

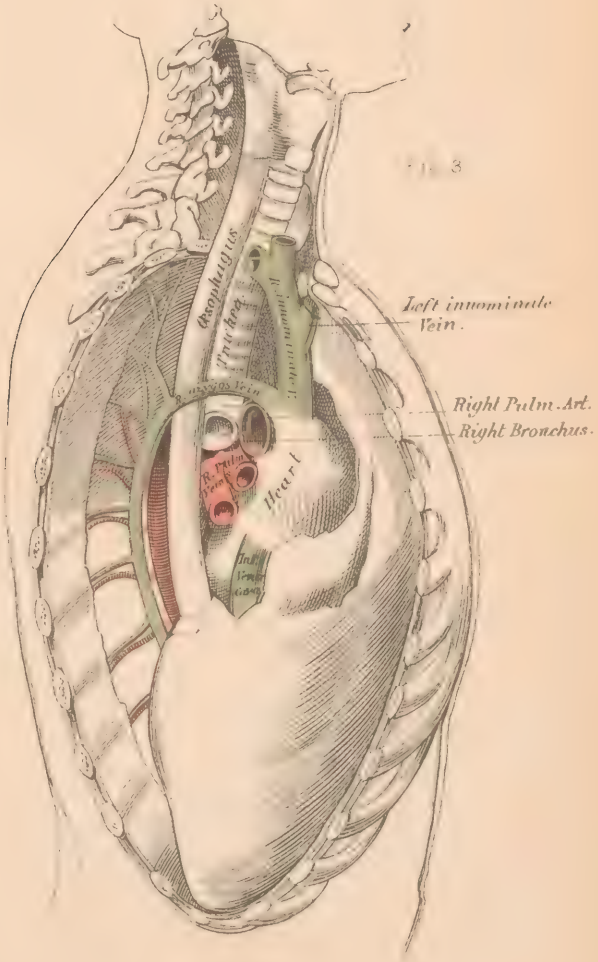


Fig 3.

costal space, directly to the left side of the sternum, the right margin of the vessel answering nearly to the left border of the bone. On either side of the origin of the vessel lie the two auricular appendages.

The margin of the left lung is placed in front of the pulmonary artery. When this is retracted, as in pleurisy, the pulmonary artery lies against the chest-wall.

About on a level with the second costal cartilage the vessel divides into two branches—the right and the left pulmonary branches.

The right pulmonary branch is the longer and stouter of the two. It passes transversely to the right side, beneath the ascending portion of the aortic arch and superior vena cava, to the root of the lung, where it divides into three branches, which enter the lung substance.

The left pulmonary branch is directed less horizontally than the right. It passes in front of the left bronchus, behind the ascending portion of the aortic arch, to the left lung, where it divides into two branches before entering the lung substance. The vessel adheres to the arch of the aorta at the point where remains of the ductus arteriosus are found, and passes in front of the descending aorta.

The ductus arteriosus thus lies to the left side of the point of division of the pulmonary artery, and joins that artery and the under surface of the aorta. In fœtal life the ductus receives the greater volume of blood flowing through the pulmonary artery.

The walls of the pulmonary artery collapse after death.—Both the main vessel and the branches are in relation with the visceral or serous layer of the pericardium.—Filaments of the sympathetic nerve passing to join the coronary plexus lie upon the vessel.

Remarks.—The pulmonary semilunar valves are rarely increased to four. The additional valve is generally smaller, though it may be as large as the others.[1] Dr. Norman Chevers[2] has described a specimen preserved in the museum of Guy's Hospital, in which the additional valve was without a corpus Arantii, but presented a thin membranous bridle which extended upward from the usual position of the corpus Arantii to the wall of the artery above. This arrangement recalls the normal disposition of the parts as seen in the shark.

The pulmonary artery may be double, and yet the heart be normal.—Rupture of the pulmonary artery both above and beneath the line of the reflected pericardium has been recorded.

The plane of the semilunar valves of the pulmonary artery is slightly above the plane of the analogous valves of the aorta.

[1] Dr. Jenner, Trans. Path. Soc. London, iv. 1853, 102, also C. H. Carter, Trans. Path. Soc. London, 1873, 48.

[2] London Med. Gaz., 1846, 834.

THE PULMONARY VEINS.

The Pulmonary veins (figs. 2 and 3, Plate LVIII.; fig. 2, Plate LIX.; fig. 4, Plate LX.; figs. 2 and 3, Plate LXI.) are four in number, two on each side, and are somewhat larger than the corresponding pulmonary arteries. They convey arterial blood from the lungs to the left auricle.

Their course is transversely inward and slightly downward. Their terminal portions, as a rule, are covered in front with the serous layer of the pericardium. Those of the right side are longer than those of the left. The vessels on both sides enter the left auricle at the sides, near the summit. The veins may be said to lie behind the third costal cartilage.

The radicles of the pulmonary veins within the lung substance lie behind both arteries and bronchi. At the root of the lung the veins lie in front of both artery and bronchus. The right veins pass below the pulmonary artery and behind the superior vena cava, the right auricle, and the ascending aorta. The left veins pass in front of descending aorta.

Variations.—The pulmonary veins rarely unite to form a single trunk, but more frequently the vessels are increased in number.

The pulmonary veins may be two or three instead of four or five in number. They may, in rare malformations, enter the venæ cavæ or ventricles. In transposition of the two sides of the heart, the pulmonary veins open into the right auricle. In a case recorded by Raval Chassinat,[1] a single pulmonary vein from the left lung entered the left auricle, while the single vessel from the right lung passed through the Diaphragm, and joined the ascending vena cava.

THE SYSTEMIC ARTERIES.

THE AORTA.

The Aorta (Plates LVIII., LIX., LX., LXI.) is the largest vessel in the body. It arises from the summit of the left ventricle, and passes upward and to the right as far as the second costal cartilage. It thence curves upward, backward, and to the left, and descends along the left side of the bodies of the vertebræ as far as a point opposite the fourth lumbar vertebra, where it terminates in the two iliac arteries.

[1] Archiv. Générales de Méd., 2d série, t. xii. 1836, 81.

The aorta is divided by the Diaphragm into two portions, the thoracic and the abdominal.

The *thoracic portion* is composed of an ascending, a transverse, and a descending portion. The first two, and the descending portion as far as the fourth or the fifth dorsal vertebræ, constitute the *arch of the Aorta*. The remainder of the descending portion to the Diaphragm is commonly called the "thoracic portion" proper, in contradistinction to the arch. The "arch of the aorta" and the "thoracic aorta" will, therefore, be described separately.

The arch of the aorta. — This is composed of the *ascending*, the *transverse*, and the *descending* portions.

The *ascending* portion arises from the base of the heart, a little to the right of the septum. It passes upward, forward, and toward the right border of the sternum at the junction of the second cartilage with the sternum.

This portion of the vessel is at first in *relation* with the different parts of the base of the heart; the infundibulum of the right ventricle and the pulmonary artery lying in front.—The pericardium embraces both it and the pulmonary artery, extending higher upon the former than upon the latter.—The aorta is soon disengaged from these surroundings. It ascends obliquely, and with a slight lateral curvature to the right, as far as the second costal cartilage, as above stated. It lies immediately beneath the sternum, from which, however, it is separated by the anterior mediastinum and the pericardium. To its right is the descending vena cava, and behind is the right branch of the pulmonary artery.—The right side of the ascending portion is often slightly dilated.

The *transverse* portion of the arch lies between the second costal cartilage and the front of the trachea just above its bifurcation, and extends from the right second costal cartilage to the intervertebral substance between the fifth and the sixth dorsal vertebræ. The top of the arch answers to the lower border of the fourth dorsal vertebra, and occasionally to the third, and one inch to a half inch below the episternal notch in the adult. According to Sappey, it is nearer by four lines in the aged, and by seven lines in the infant.

Among the *relations* of this portion of the aorta may be mentioned the following: Above lies the left innominate vein, with which it is connected by fibrous tissue. The innominate artery, the left carotid, and the left subclavian arteries arise from its upper surface. Below the transverse portion are seen the bifurcation of the pulmonary artery, the remains of the *ductus arteriosus*, and the left inferior recurrent branch of the pneumogastric nerve, as it turns round to ascend the neck. The anterior surface toward its posterior portion is crossed by the left pneumogastric nerve and the phrenic nerves, and by some of the cardiac branches of the sympathetic nerve. It is in part covered by the left pleura. The posterior surface lies upon the trachea, as already mentioned, the œsophagus, and the thoracic duct.—The arch is slightly depressed during full inspiration.

The *descending* portion of the arch extends from above the tracheal bifurcation at the second dorsal vertebra to the lower border of the third dorsal vertebra. It is here crossed by the left bronchus, and is continuous with the "thoracic aorta." It is in *relation* on the right side with the œsophagus and the thoracic duct. To its left side is the pleura. Behind are the Longus Colli muscle and the vertebral column. This portion of the aorta is surrounded by a number of dark-colored lymphatic glands.

The left bronchus determines both the end of the arch of the aorta and the alterations in the relations of the œsophagus.[1]

[1] One might, with propriety, speak of the supra-bronchial portion of both the aorta and the œsophagus.

EXPLANATION OF PLATE LXII.

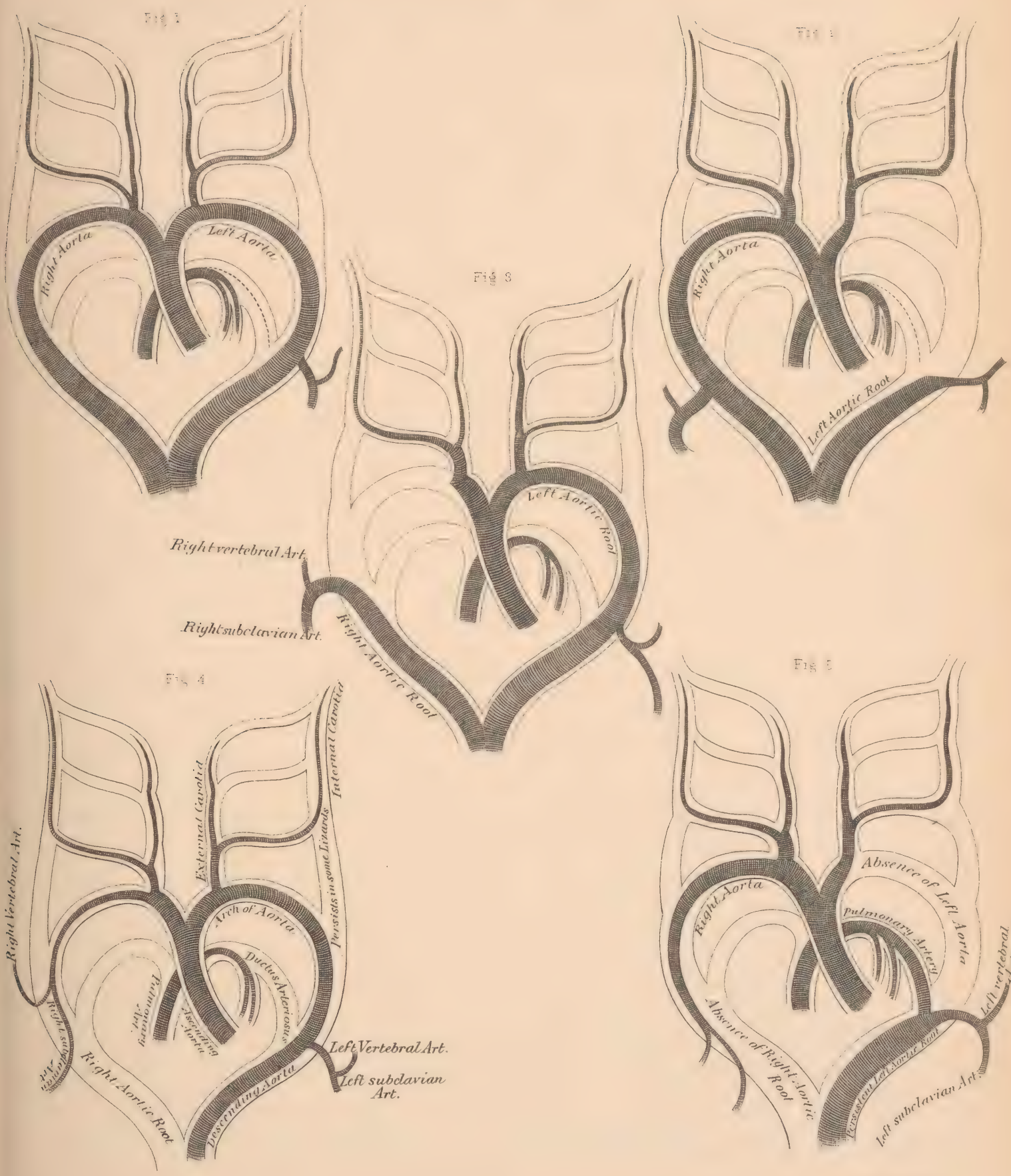
Fig. 1. Scheme of the mode of formation of a double arch of the aorta through persistence of both fourth vascular arches (see p. 348).

Fig. 2. Scheme of the mode of origin of a right aorta, and the origin of the left subclavian artery from a "pouch-like" trunk by the persistence of the left aortic root.

Fig. 3. Scheme of the mode of origin of the right subclavian artery, as the last branch of the arch of the aorta, through atrophy of the fourth right arch and persistence of the right aortic root.

Fig. 4. Scheme of the normal mode of development of the arch and great vessels in the mammal (after Ranke).

Fig. 5. Scheme of the mode of origin of the descending aorta and left subclavian artery from the ductus arteriosus and pulmonary artery. Atrophy of the fourth left arch between the left carotid and subclavian arteries. Termination of the ascending aorta in the right subclavian and right and left carotid arteries.



T. Sinclair & Son Lith.

The liability of the left bronchus to compression as compared with the right is worth noting. It is the weaker bronchus; for in an exact sense the trachea does not bifurcate, but continues both in volume and direction in the right bronchus—the left bronchus being a twig-like growth from the main stem. Hence the smaller volume of the left lung, and, probably, its greater liability to disease.

The parts contained within or beneath the arch of the aorta are:—

(1) The right pulmonary artery. (2) The portion of the left auricle with which the appendage is connected. (3) The left bronchus. (4) The cardiac ganglion of Wrisberg. (5) The ligamentous remains of the *ductus arteriosus*. (6) The recurrent branches of the pneumogastric nerves.

Opposite to the position of the semilunar valves, a slight constriction of the calibre of the aorta takes place. Directly above the plane of the insertion of the valves the aorta is slightly dilated, forming the sinuses of Valsalva.

The aortic semilunar valves are on a level with the top of the body of the eighth dorsal vertebra, and the spine of the sixth dorsal vertebra. In front their position answers to the middle of the sternum, or they may be on a line with the junction of the sternum and the third costal cartilage.

The average circumference of the adult aorta above the semilunar valve is two inches and eight and a half lines; and below the valves three inches and a fourth of a line.[1]

The semilunar valves are rarely two in number; either the right and the left may coalesce, or the posterior valve may be absent.

Variations of the Aorta.—The following are among the most striking of the varieties of the arrangement of the aortic arch and its branches:—

The right aortic arch present in common with the left. This is constant in many Batrachia. The arrangement is due to the retention of the fourth right brachial arch.

The ascending aorta forming a ring, which gives off from its periphery the subclavian, external carotid and internal carotid arteries. The pulmonary artery passes backward through the ring.[2]

The arch of the aorta crosses the trachea just above its bifurcation. The right subclavian and common carotid arteries arise from the posterior and the left common carotid, and the left subclavian from the front.[3]

The right aortic arch is persistent, the left is absent. This arrangement is constant in the birds. The arch of the aorta passes behind the trachea. The innominate artery, the left common carotid, and the left subclavian arise from the beginning of the arch of the aorta in front.—The left subclavian may arise from the ascending portion of the aortic arch, and pass to the left behind the trachea. It may also arise from the summit of the arch, and the right subclavian artery take its origin from the junction of the arch with the descending portion, and pass to the right behind the trachea and œsophagus.—The right subclavian artery may arise from the descending portion of the aorta, and pass to the right side under the aortic arch.—The arch of the aorta may yield, in addition to its usual branches, the arteria thyroidea ima, and the vertebral artery.—The innominate artery may be absent, and its place supplied by the right subclavian and right common carotid having distinct points of origin. The anterior aortic roots may unite into a single trunk.—The left carotid may be united with the innominate. —The left carotid and subclavian may unite to form a left innominate. This is constant in birds.—The common carotids may unite, leaving the subclavians distinct.—The innominate may give origin to the subclavian and carotid arteries, leaving the left vertebral to arise separately.

In the chests of persons deformed by rickets, the aorta may be so curved as to make its pulsations visible either to the right or left of the sternum, in this way simulating an aortic aneurism. Of this peculiarity, Barkow[1] has figured a number of examples, in one of the most remarkable of which the ascending aorta lay directly behind and in contact with the surface of the chest, from the second to the fourth ribs on the right side, and from the second and third ribs on the left. Balfour[2] has discussed this subject from a clinical point of view.

The aortic bulb may be imperfectly divided, so that a septum is seen within. The anterior roots of the primordial aorta may imperfectly unite, and persist as a septum within the ascending aorta. The division of the aortic bulb into the origin of the aorta and the pulmonary artery, while complete, may transpose the vessel in such wise that the pulmonary artery is posterior, and the aorta is anterior. In five cases collected by Albers,[3] the pulmonary artery sprang from the left, the aorta from the right ventricle; in all death ensued within a few months after birth. In two cases of Fane's, the pulmonary artery arose from both ventricles. "The proper aorta gave off the arteries of the head and of the upper extremities only, and united by a thin branch with the descending aorta, which was derived from the pulmonary artery, *beyond* the point where the latter sent off its branch to the lung."

The Relations of the Aorta specially considered in connection with aortic aneurism.—The portion of *the aorta within the pericardium* differs in some import-

[1] N. Chevers, Lond. Med. Gaz., 1846, 191.
[2] Malacarne, Osservaz. in Chirurg., 1788, ii. 119.
[3] Hommel, Commerc. Litter., Norimb. 1737, 161.

[1] Die Verkrummungen der Gefässe, etc., Breslau, 1869.
[2] Diseases of the Heart, etc., London, 1876, 320.
[3] Martin Müller, Archiv, 1839, fasc. 3, p. 222.

ant features from the rest of the vessel. It is imbedded in the body of the heart, being surrounded by the various walls, cavities, and vessels. The right ventricle and the auricular appendage of the right auricle are in front of the aorta, the pulmonary artery is on its right side, the right auricle and the vena cava are on its right, and the left auricle and the right branch of the pulmonary artery are behind it. Its outer covering is the inelastic, inextensile serous lining of the pericardium. Hence, when this portion of the aorta is the seat of aneurism, rupture occurs either into the pericardial sac, or into one of the chambers of the heart. Sibson[1] has concluded, from the study of many cases, that this aneurism ruptured in 80 per cent. of all cases; in 45 per cent. of this proportion the sac opened into the pericardium, in 13.5 per cent. into the pulmonary artery, in 8.5 per cent. into the right auricle, in 5 per cent. into the right ventricle, and in 5 per cent. into the left ventricle.

The aorta *beyond the limit of the pericardium* is less liable to rupture under aneurismal distension. The vessel is relatively mobile through its ascending and transverse portions, and varies slightly in position in accordance with the movements of respiration. Thus, the descent of the aorta during inspiration "is much greater than that of the upper portion of the descending aorta. The play of the transverse is less than that of the ascending, and greater than that of the descending aorta. During inspiration the ascending aorta is somewhat straightened as well as lowered, and the curve of the arch is rendered more acute."[2]

The explanation of these facts is simple. The aorta, as it approaches the vertebral column, becomes more fixed, and in the descending portion, from the arch downward, is held immobile by the intercostal arteries. For the same reasons the pain of an aneurism will be greater when the fixed portion of the aorta is affected. Implication of the pneumogastric and sympathetic nerves will excite cough and aphonia in thoracic aneurism, and epigastric or general abdominal pain if the lesion be seated in the abdominal region. Pressure over the spinal nerves as they pass out through the intervertebral foramina will excite radiating pain, which will be limited by the distribution of the groups of nerves actually compressed. Thus, an aneurism at the beginning of the descending aorta will cause intercostal pain; one further down in the thorax, pain in the parietes of the abdomen; while in the lumbar region, the branches of the lumbar plexus being compressed, pain will be complained of in the groin and inner part of the thigh.

Aneurism of the ascending aorta is apt to be associated with disease of the heart (the pneumogastric and sympathetic nerves being largely interested), and angina pectoris to prove a prominent symptom.—*Aneurism of the arch*, and of the great vessels arising from it, would create aphonia and harsh breathing by pressure on the recurrent laryngeal nerves.—*Aneurism of the descending portion*, in addition to the fixed pain already mentioned, would excite attacks of dyspnœa, palpitation, and angina by pressure on the branches of the spinal nerves going to the cardiac plexuses and to the Diaphragm.

The termination of aortic aneurism by rupture of the sac leads to hemorrhage into the numerous adjacent structures. Thus, in the *ascending aorta*, Sibson found in 57 instances that the sac opened into the pericardium 22 times, externally 8, descending vena cava 5, right lung 5, pulmonary artery 4, left pleura 4, right bronchus 3, left lung 2, right pleura 2, trachea 1, right auricle 1. The most common localities of infiltration from rupture of the descending aorta are the following, named in the order of their frequency: pleura, left bronchus, right lung, left lung, abdomen, retro-peritoneal space, peritoneal cavity, mesentery, left pleura, duodenum, and right pleura.

Pressure from an aneurismal tumor may involve any of the adjacent parts; thus, the pulmonary artery may be occluded as well as the œsophagus. The bodies of the vertebræ may be extensively eroded. In the abdomen, the kidneys may be displaced to the side or the front of the sac, or obstruction of the colon may occur.

In a case of complete obliteration of the aorta at the ductus arteriosus, recorded by Sydney Jones,[1] the *collateral circulation* was established by the internal mammary arteries anastomosing with the musculophrenics, and the branches accompanying the phrenic nerves, as well as with the deep epigastric arteries. The superior intercostal arteries anastomosed with the first aortic intercostal. The last-named vessel joined with a branch of the inferior thyroid artery, and the posterior branch of the aortic intercostal with the transversalis colli.

The aorta, when ruptured by injury from without, presents a free and unobstructed opening instead of the small one commonly seen in the bursting of an aneurism.[2]

[1] Medical Anatomy. [2] Sibson, loc. cit.

[1] Trans. Path. Soc. Lond., viii., 1857, 161.
[2] Sibson, loc. cit., col. 53.

THE CORONARY ARTERIES.

The Coronary Arteries are two in number, the right and the left. They arise from the anterior aspect of the aorta, opposite the two anterior of the three sinuses of Valsalva. Both the arteries are very tortuous. The vessels pass downward and slightly outward on either side of the infundibulum.—The *right coronary artery* is the larger. It arises nearly behind the infundibulum, and passes along the right auriculo-ventricular groove to the posterior surface of the heart. Opposite the posterior inter-ventricular groove, it divides into two branches, one descending the groove to be lost toward the apex of the heart, the other passing transversely in the auriculo-ventricular groove toward the left border of the heart. The branches of the right coronary artery are chiefly distributed to the right ventro-posterior wall of the left ventricle. Several smaller branches supply the left ventricle.—The *left coronary artery* passes obliquely downward to the left, between the pulmonary artery and the left auricular appendage. It lies for the most part in the anterior inter-ventricular groove. A transverse branch follows the direction of the left auriculo-ventricular groove. The artery supplies the left auricle and the corresponding auricular appendage, and sends some small nutritive branches to the pulmonary artery and the aorta.

Notwithstanding the statement generally made to the contrary, the coronary arteries have a feeble communication with one another. The trunks may be three or four in number.

The coronary arteries are rarely the seat of aneurism, the right vessel being the one more frequently affected. They are peculiarly liable to atheromatous deposit.

THE INNOMINATE ARTERY.

The Innominate artery (brachio-cephalic) (fig. 2, Plate LIX.; figs. 1, 2, Plate LXI.) arises from the beginning of the transverse portion of the aortic arch, passes obliquely upward and backward toward the right, and is the most superficial of the branches of the arch. It measures from one to fifteen lines in length, terminating opposite the right sterno-clavicular articulation in the right subclavian and right carotid arteries.

Relations.—In front lie the sternum, the Sterno-Thyroid and Sterno-Hyoid muscles, the remains of the thymus gland, the left innominate vein, the right inferior thyroid vein, and, in inspiration, the median edge of the right lung. The vessel crosses the trachea obliquely. To the right side, and a little in front of the artery, are the right innominate vein and the pleura. The right pneumogastric nerve is seen between the right innominate vein and the artery, but on a lower plane. To the left is the left common carotid, separated by a small triangular interval, within which the trachea appears. To the front and the left on the same side the remains of the thymus may also be seen.

In infants, and occasionally in adults, the innominate artery crosses the trachea at a point so near the level of the upper margin of the sternum as to be included within the contents of the base of the neck. A knowledge of this fact is of great importance to the surgeon, both in the performance and in the after-treatment of tracheotomy. Incautious use of the knife may open the vessel, while the pressure of the tracheal tube may induce ulceration and fatal hemorrhage.

The great vessels do not arise from the arch of the aorta as vertical stems, but are more or less obliquely placed to the arch, forming a cone-like figure whose base is upward. The innominate artery is slightly inclined from the median line toward the right, while the left carotid and subclavian are inclined from the median line toward the left. The carotid is nearer to the innominate than to the subclavian.

According to Richard Barwell,[1] "if the ascending aorta be severed from the rest, a little to the proximal side of the innominate, and we look along the tube of the transverse part, we do not see the orifices of the carotid and subclavian vessels foreshortened into an oval or mere slit, as would be the case if these vessels were given off straight and plumb from the parent stem, but they look nearly round. If a little hole be made in each carotid, just below its bifurcation, and a probe be passed along each common trunk, as far as it will go without the use of force, and if, then, the front wall of the chest, etc. be removed, and the ascending aorta carefully opened, the two probes will be found crossing within the vessel. The right one will be seen to pass through the aortic opening, not far from its left margin, and to lie well in the ventricle. The left one will be seen to strike the tendinous ring of the aortic orifice on the right side of the vessel. The probe is never in the axis of the ascending aorta, but strikes the wall at a considerable angle." This writer gives reasons for believing that a *concretion detached from an aortic valve* almost invariably passes into the left carotid (sometimes into the left subclavian, but into the right carotid only once in twenty-five times), and conceives that the current of blood issuing from the aortic orifice follows a course the shortest line of which is in the position of the probe passing from the left common carotid to the right of the aortic orifice. The most potent rush of the stream would be, therefore, somewhat obliquely across the ascending aorta in the direction of the left carotid.

The artery may lie in front of the trachea. In forced expiration the lung retires from in front of the innominate

[1] Med.-Chir. Trans., lxii. 396.

artery, where it is possible for the position of the vessel to be detected by a dull percussion note heard over the sternum below the sterno-clavicular junction.

THE COMMON CAROTID ARTERIES.

The *Right* Common Carotid artery (figs. 1 and 2, Plate LIX.; figs. 1 and 2, Plate LXI.; fig. 2, Plate LXIII.) arises from the innominate artery, while the *left* common carotid arises from the arch of the aorta. Within the region of the neck, both vessels ascend as far as the upper border of the thyroid cartilage or the third cervical vertebra, at which point they end, by division, in the internal and external carotid arteries.

Relations.—Each vessel lies on a line midway between the mastoid process and the angle of the lower jaw. Lying deep at the base of the neck, it becomes more superficial on either side of the larynx. Superficially to it lie the Sterno-Cleido-Mastoid muscle, the Platysma-Myoides, the omo-hyoid branches of the superior thyroid vein, and the descendens noni nerve. The thyroid body may slightly overlap it. To the outer side lies the internal jugular vein. Since both the right and the left internal jugular veins terminate toward the right, the left vein tends to cross the carotid at its lower portion. To the inner side lies the trachea. Beneath, and in part to the outer side, is the pneumogastric nerve. The anterior tubercles on the transverse processes of the cervical vertebræ are guides to the position of the vessel. The inferior laryngeal nerve lies behind the carotid.

Variations.—The common carotid normally gives off no branches. Very infrequently the inferior thyroid arises from its lower part. The artery may give off the superior thyroid, and, when on a level with the hyoid bone, may divide into the external and internal carotid branches.[1] The termination of the common trunk in the internal and external carotid may occur at a lower point than the one assigned in the text. The vessel may be absent, when both the arteries last named will arise separately from the aorta.

The right artery arises from about the level of the second dorsal vertebra. As it lies within the thorax it is more superficial than the left, and is seen at its origin nearly in the median line, but inclines to the right, and lies at the base of the neck behind the sterno-clavicular articulation. Over it is the right innominate vein. The subclavian vein lies to the outer side.

The left artery is longer than the right, and is the more deeply seated. It ascends nearly vertically, and lies on the trachea and œsophagus. Behind it is the thoracic duct. It is crossed by the right innominate vein. On the outer side lie the pleura and the pneumogastric and phrenic nerves.

Remarks.—The suppurative processes about the cervical lymphatic glands following scarlet fever may expose and even ulcerate through the walls of the common carotid artery. Mr. Wm. Cayley[1] has recorded an instance occurring in a boy, aged eighteen, in whom suppuration about the glands at the angle of the right inferior maxilla had excited angina. On the tenth day of the pharyngeal complication a profuse hemorrhage occurred from the throat. Ligation of the common carotid was in vain tried to save the life of the patient, who died five hours after the operation. At the autopsy the tonsils were enlarged, but not ulcerated. The posterior wall of the pharynx, above and to the left of the soft palate, was perforated by a small ragged opening leading to an irregular cavity two to three inches in diameter. Directly within this cavity was an opening in the left common carotid artery one-half inch below its point of entrance into the temporal bone.—In a case of cancer involving the pharynx, recorded by E. Desnos,[2] death occurred from rupture of the common carotid artery into the pharynx.

The greater frequency with which the left internal carotid artery is plugged by emboli is due to the fact that the left common carotid arises directly from the aorta, while the right arises from the innominate.[3] When the oblique position of the innominate artery is recalled, it is evident that a clot thrown into this vessel will not of necessity enter the common carotid, and if it does so the force carrying it is already somewhat diminished.

Ligation of the Common Carotid above the Omo-Hyoid Muscle.—An incision three inches long should be made extending downward from the angle of the inferior maxilla to the cricoid cartilage. The fascia being divided the entire length of the wound, the sheath of the great vessels is exposed, the descendens noni nerve being usually seen passing downward upon it. The remaining steps of the operation are the same as in the operation below the Omo-Hyoid. It is well to remember that the communicans noni nerve sometimes lies within the sheath.

Ligation of the Common Carotid below the Omo-Hyoid Muscle.—An incision is made parallel to the inner border of the Sterno-Cleido-Mastoid muscle extending downward three inches from the level of the cricoid cartilage. The fascia is carefully opened at the lower end of the incision, so as to permit the entrance of a grooved director, and is divided the length of the first incision. It is necessary to carefully avoid the anterior jugular vein in this stage of the operation. Retractors are then used to draw the Sterno-Cleido-Mastoid muscle outward and the integument inward. If the muscle be unusually well developed, it may be divided to a degree sufficient to secure a free exposure of the deeper

[1] Jæssel, Archiv für Anat. und Entwickelungsgeschichte, 1878.

[1] Trans. Path. Soc. London, 1865, 85.

[2] Bull. de la Soc. Anatom., 1878, t. 53, 395.

[3] Duret, Archiv. de la Phys., 1874.

parts. A second layer of fascia over the Sterno-Hyoid and Sterno-Thyroid muscles is next divided, when the sheath of the vessels is exposed. Upon the sheath the descendens noni branch of the hypoglossal is ordinarily seen. Carefully avoiding this nerve, the sheath is opened by making a small puncture, and the ligating needle is passed from without inward. The internal jugular vein lying to the outside need not be seen. In some individuals it is seen expanding in inspiration, and collapsing in expiration. The pneumogastric nerve lies beneath the artery. The sympathetic nerve lies still deeper behind the sheath. The proximity of these important structures should make the operator careful in the manipulation of the needle in encircling the artery.

Collateral Circulation.—Dr. Valentine Mott,[1] in the dissection of the head and neck of a man, three months and a half after ligation of the right common carotid artery, found the distribution of the collateral vessels as follows:—

The right subclavian artery was enlarged to the size of the innominate. The thyroid axis gave off four branches—the inferior thyroid, the deep cervical, the transversalis colli, and the supra-scapular. The first two of these were greatly enlarged. The ascending cervical was remarkable for being three times its normal size. It formed numerous anastomoses with the vertebral, and divided into many small branches at the upper part of the neck, and united with the descending cervical branch of the occipital artery. The left carotid was also greatly enlarged, as were all the branches arising therefrom—especially the facial and temporal vessels. Much of the blood from the left carotid passed over to supply the tissues on the right side of the head and neck.

Ligation of the common carotid artery is not infrequently succeeded by hemiplegia. Lefort,[2] in analyzing 241 cases, found cerebral lesions to follow in 75. According to Duret,[3] such consequences are due either to an embolus detached from a clot above the ligated point, or to complete absence of a collateral circulation. Both the anterior and posterior communicating arteries may be mere threads, or the vessels of one side may be in all their proportions smaller than those of the opposite side. If the trunk carrying the larger volume of blood be ligated, the other is not sufficiently capacious to nourish the brain. Extensive atheroma of the arteries of the base of the brain may induce the same lack of nutrition, but the more important source of cerebral anæmia lies in the absence of anastomosis between the arteries of the two sides, as well as between arteries of the same side.

THE EXTERNAL CAROTID ARTERY.

The External Carotid artery (figs. 2 and 3, Plate LXIII.) is the median of the two terminal branches of the common carotid artery. It arises opposite the upper margin of the thyroid cartilage, and ascends the neck between the pharynx and the prevertebral muscles as far as the neck of the lower jaw, where it ends in the internal maxillary and the temporal arteries. It supplies the larynx, the pharynx, the tongue, the facial region, the temples, the external and the middle ear, the occiput, and the dura mater. It consists of two portions, that below the parotid gland, or the superficial, and that within the parotid gland, or the deep-seated.

Relations.—At its origin the *superficial* portion is covered by the skin, the Platysma Myoides, and the cervical fascia. It lies to the inner side of the internal carotid artery, while behind it lies the superior laryngeal nerve. A little higher up the same relations are maintained, with the addition that the Digastric and Stylo-Hyoid muscles are placed *superficially* to the artery. The posterior belly of the Digastric thus becomes the best guide to the artery.

The *deep* portion of the artery is embraced by the cervical lobe of the parotid gland during the remainder of its course. The external carotid artery ordinarily possesses no accompanying vein. When, however, the internal maxillary vein joins the deep instead of the superficial jugulars, the artery retains the vein in a superficial relation.

Variations.—The tendency is for the branches of this artery to unite at or near their origin. The superior thyroid and the lingual may unite, or both of these may join with the facial, or the facial and the lingual may form a common trunk, while the superior thyroid remains in its usual relation or arises from the common carotid. These tendencies permit the origin of many branches to be sought with success in the first or superficial portion of the artery, the posterior belly of the Digastric muscle being a guide to them all. The main trunk of the vessel arising from this cluster of branches may pursue the rest of the course without any branches near its terminal ones.

In other instances—indeed, those commonly given as the rule—the branches are given off at somewhat regular intervals along its course. The artery may divide into two branches at the angle of the lower jaw, which branches reunite behind the neck of the same bone to form the temporal.[1] Rarely the internal maxillary pierces the Internal Pterygoid muscle, and thence enters the spheno-maxillary fossa. It may pass between the Digastric and the Stylo-Hyoid muscles.

Ligation of the External Carotid Artery.—To ligate the vessel *below* the Digastric, an incision should be made along the neck midway between the angle of the inferior maxilla and the Sterno-Cleido-Mastoid muscle to the thyroid cartilage. The Platysma Myoides muscle and the deep fascia must be next divided. The facial and the superior thyroid veins and an occasional lymphatic gland may then come into view. The artery is crossed by the posterior belly of the Diagstric, and by

[1] Medical and Surgical Register, 1818-20, 49, fig.

[2] Bull. de la Soc. de Chir. iv. See also G. W. Norris's Contributions to Practical Surgery, p. 256.

[3] Archiv. de la Phys. 1874, 66.

[1] Jaessel, Archiv für Anat. und Entwickelungsgeschichte, 1878.

the Stylo-Hyoid muscle, which must be drawn upward and forward. It is well, when practicable, to expose the vessel at its origin from the common carotid, to be sure of ligating the main trunk below the point of origin of the superior thyroid. The needle should be inserted from without inward. The internal carotid artery and possibly the internal jugular vein may be seen, as well as the hypoglossal nerve, which crosses the vessel near the posterior belly of the Digastric muscle.

In ligating the vessel *above* the Digastric, the procedures are the same as those above given, with the exception that the relation with the parotid gland is to be noted, and that this structure should be drawn outward.

The point usually selected for the application of the ligature is from four to six lines above the point of bifurcation of the common carotid into the external and the internal carotid trunks, and between the origin of the superior thyroid and that of the lingual arteries, a distance of about half an inch. L. R. Longworth[1] found it to be less than this in eight instances out of twenty-eight examinations.

The *collateral circulation* after ligation of the external carotid is readily established through the free anastomosis existing between the branches of the ligated vessel and those of the external carotid of the opposite side.

In a ligation of the vessel for an aneurism on the common carotid artery at the origin of the external carotid, recorded by Mr. A. Poland, the ligature at first failed to check the bruit.[2] This was attributed to the free entrance of blood down the external carotid into the sac. The sac, however, gradually filled with coagula, and a cure resulted.

The cervical branches of this artery are capable of forming a vascular growth which simulates aneurism of the common carotid artery. A case of this kind has been recorded by Kerr.[3] A woman of thirty-seven was observed to have a small pulsating tumor behind the angle of the inferior maxilla. At the end of three years it began to extend downward, and at the age of sixty-seven it had reached the sternum. The common carotid artery was now tied. Nine months afterward the patient died of pneumonia. No aneurism was found, but a vascular tumor, as above described, was seen to be supplied by the external carotid artery.

The following include the branches of the External Carotid artery :—

[1] Archives for Scientific and Prac. Med., 1873, 403.
[2] Med. Times and Gazette, 1868, 528.
[3] Edinburgh Med. and Surg. Journ. lxi.

Directed inward (medianly).
- The Superior Thyroid.
- The Lingual.
- The Facial.

Directed outward (laterally).
- The Occipital.
- The Posterior Auricular.

Directed upward.
- The Temporal.
- The Internal Maxillary.
- The Ascending Pharyngeal.

The branches of the external carotid mostly arise near one another below the parotid or deep portion of the vessel.

THE SUPERIOR THYROID ARTERY.

This artery arises from the external carotid, on a level with the hyoid bone. It passes forward and downward to supply the hyoid bone, the larynx, and the muscles depressing the hyoid apparatus, and terminates in the thyroid gland.

As it crosses the interval between the great vessels and the larynx it is curved, with its concavity upward. It is covered anteriorly by the superior belly of the Omo-Hyoid muscle, by some small laryngeal veins, and by the Platysma and skin.

Its branches are—

(*a*) Hyoid.
(*b*) Muscular.
(*c*) Superior Laryngeal.
(*d*) Crico-Thyroid.
(*e*) Terminal.

(*a*) The *hyoid branch* passes beneath the Thyro-Hyoid muscle, and supplies the hyoid bone and adjacent parts. It is small, and not infrequently effects a direct anastomosis with the corresponding artery of the opposite side.

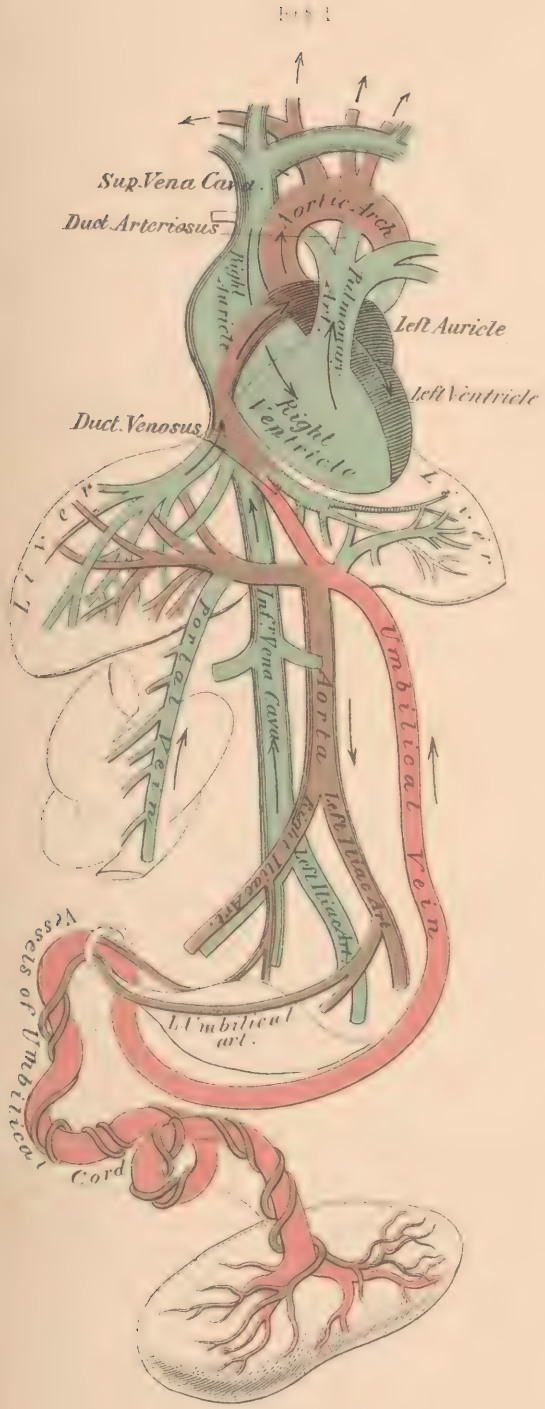
Dr. L. S. Pilcher[1] reports (not, however, as having occurred in his practice) an interesting case in illustration of the importance of this small and apparently insignificant vessel. A child, nineteen months old, who had drawn during inspiration a portion of a vertebra of a fish within the larynx,

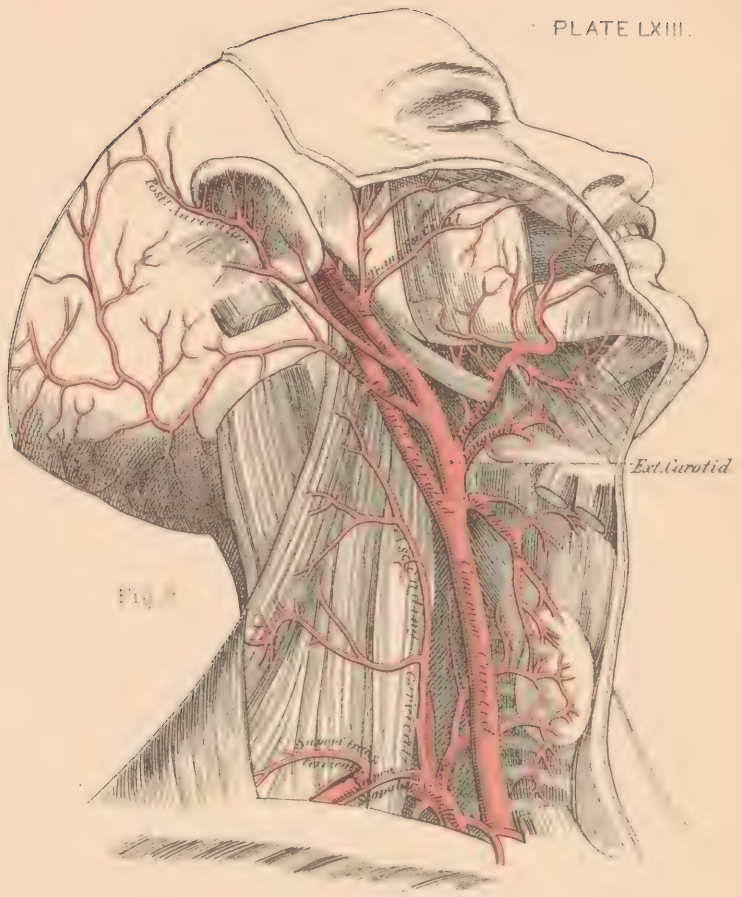
[1] Annals of Anat. and Surg., 1881, 160.

EXPLANATION OF PLATE LXIII.

Fig. 1. A diagram of the fœtal circulation.
Fig. 2. The arteries of the side of the neck and face.
Fig. 3. The external carotid artery and its branches.

PLATE LXIII.







T. Sinclair & Son, Lith.

was subjected to laryngotomy in consequence. An incision was made in the thyro-hyoid space, when the sudden collapse and cessation of breathing in the little patient caused the operator to abandon the operation, and to substitute tracheotomy and insert a tracheotomy-tube. Further attempts to remove the foreign body were postponed until complete reaction should be obtained. At the end of two hours and a half the child made an attempt to cough, threw out a quantity of blood from the tracheotomy-tube, and then suddenly expired. Upon examination the air-passages were found filled with blood. No external oozing having occurred at the site of the tracheal incision, which was occupied by the tracheotomy-tube, the reporter infers that the hemorrhage had taken place from the divided hyoid artery.

(*b*) The *muscular* branches supply the Omo-Hyoid, Sterno-Thyroid, Sterno-Hyoid, and Sterno-Cleido-Mastoid muscles, entering their under surfaces. The branch to the Sterno-Cleido-Mastoid is interesting from its position over the sheath of the great vessels.

(*c*) The *superior laryngeal* branch enters the larynx through the thyro-hyoid membrane, in company with the superior laryngeal nerve. It then divides into a superior and an inferior branch. The former supplies the posterior surface of the epiglottis and its mucous membrane; the latter, the intrinsic muscles of the larynx, and the laryngeal mucous membrane.

(*d*) The *crico-thyroid* branch crosses the membrane of the same name. Its presence must be borne in mind in performing the operation of laryngotomy.

(*e*) The *terminal* branches end in the thyroid body. One of these enters the body upon its posterior surface; another extends along the lateral border; a third dips within the upper border. The terminal branches of both superior and inferior thyroid arteries freely anastomose.

The artery often sends a branch along the upper border of the isthmus and within the capsule of the thyroid body. When anastomosing with the artery of the opposite side, this is often spoken of as the *transverse artery;* this vessel may be of large size, and its several branches overlie the front of the isthmus.

Variations.—The artery may be a branch of the common carotid. It may arise in common with the facial or lingual arteries, or both. The branch to the Sterno-Cleido-Mastoid muscle may be a distinct branch of the External Carotid.

The superior thyroid artery may interchange with the vessel of the opposite side.—It may give off the ascending pharyngeal.—The superior laryngeal branch often pierces the space between the thyroid and cricoid cartilages, or passes into the larynx by a foramen in the thyroid cartilage. The crico-thyroid interchanges with the branch to the thyroid body or with a branch of the inferior thyroid artery.

The surgical value of this artery is confined to the facts that it is often divided in attempts at suicide, and that its partial control over the nutrition of the thyroid gland has led to its ligation in endeavors to cure bronchocele.

Ligation of the Superior Thyroid Artery.—To reach the origin of the superior thyroid artery the procedure for the ligation of the external carotid below the Digastric muscle is recommended.

To reach it at a point between its origin and distribution, its position along the upper lateral border of the thyroid body will serve as a sufficient guide.

THE LINGUAL ARTERY.

The Lingual artery arises just above the end of the great cornu of the hyoid bone. It passes forward in a curved line, the concavity being downward, to the outer border of the Hyo-Glossus muscle. Under the cover of this muscle it reaches the side of the tongue, and continues within this organ as far as its tip where it terminates in the ranine artery.

The artery thus presents two distinct portions: the one extending from its origin to the tongue; and the other within the region of the tongue, considering this to include the space covered by the Hyo-Glossus muscle.

Relations.—The relations of the first portion are as follows: It rests upon the connective tissue and the middle constrictor of the pharynx; above it is the hypoglossal nerve. In front are the skin, cervical fascia, and Platysma Myoides muscle. Within the region of the tongue, the artery at first lies between the Hyo-Glossus and Genio-Glossus muscles, the hypoglossal nerve lying upon the former muscle. Beyond the Hyo-Glossus the artery is in close contact with the intrinsic muscles of the tongue, *i. e.*, between the Genio-Glossus and Lingualis.

The branches of the lingual artery are—

(*a*) Hyoid.
(*b*) Dorsalis Linguæ.
(*c*) Sublingual.
(*d*) Ranine.

(*a*) The *hyoid* branch supplies the parts about the hyoid bone and the fibro-adipose tissue between it and the base of the epiglottis.

(*b*) The *dorsalis linguæ* artery supplies the dorsum at its base. It commonly arises from the main artery beneath the Hyo-Glossus muscle. When well developed, it supplies in addition the Stylo-Glossus muscle and the tonsil.

(*c*) The *sublingual* is an inconstant branch, which supplies the salivary glands beneath the tongue and the adjacent mucous membrane. It is rarely a branch of the facial artery.

(*d*) The *ranine* or *terminal* branch lies beneath the tip of the tongue. Its chief importance consists in the danger of excessive bleeding following a wound of the free end of the tongue. In attempts to divide the lingual frenum in so-called "tongue tie," the ranine artery has been wounded, and, the apparently slight hemorrhage being increased by the act of sucking, serious results have been known to ensue. These are avoided by incising the frenum with a pair of blunt-pointed scissors, and directing the blades downward before cutting, while the tip of the tongue is raised.

The extraordinary independence of the nutrition of the two halves of the tongue is in part explained by the fact that the right and left lingual arteries have fewer anastomoses than most other arteries.

Variations.—The lingual artery may lie on the Hyo-Glossus muscle, and be accompanied by the hypo-glossal nerve. It may arise from the internal maxillary artery. It may be absent on one side; the vessel of the opposite side taking its place.[1] The lingual artery may arise from a common trunk with the facial. It may give off the facial and the internal maxillary and the ascending pharyngeal arteries.—The dorsal branches may be multiple, or may be represented as a union of two or more branches. The hyoid branch may interchange with the crico-thyroidean branch of the superior thyroid artery.

Ligation of the Lingual Artery.—An incision two and a half to three inches in length from the anterior edge of the Sterno-Cleido-Mastoid muscle directed forward one-half inch below the inferior maxilla and parallel with it, is the best for this operation. The guides for its exposure are first the free end of the great cornu of the hyoid bone, and afterward the hypo-glossal nerve as it crosses the sulcus between the region of the larynx and the Sterno-Cleido-Mastoid muscle. The nerve being found, the lingual artery is seen lying below it.

For ligation of the artery as it lies under the Hyo-Glossus muscle, it is necessary to prolong the incision to a point nearer the median line, the head being thrown upward and backward, and carefully maintained in this position in order to make the supra-hyoid space as large and as superficial as possible. The guides for the position of the artery are the cornu of the hyoid bone and the hypoglossal nerve. The submaxillary salivary gland and its covering of deep cervical fascia being turned upward, the intermediate tendon of the Digastric muscle is seen, above which is the hypoglossal nerve lying upon the Hyo-Glossus muscle. The nerve being drawn upward the muscle is divided upon a grooved director, leaving the artery exposed beneath. The artery needle is passed from above downward.

Mr. Moore[2] tied the lingual artery in a case of cancer of the tongue. The ulcer became paler after the operation, but neither sloughed nor healed, and in five weeks the whole tumor was perceptibly smaller than before the operation. From that time the tumor began to increase, the patient, however, having greater comfort than before.

[1] E. Zuckerkandl, Wien. Med. Wochenschrift, No. 29, 833, 1881.
[2] Proc. Med. and Chir. Soc., 1862.

THE FACIAL ARTERY.

The Facial artery arises from the external carotid above the lingual. The vessel passes upward and forward to gain the face, and, assuming a tortuous course, terminates at the side of the root of the nose.

It is divided by the edge of the lower jaw into a cervical and a facial portion.—The *cervical portion* is less tortuous than the facial. It lies upon the Mylo-Hyoid muscle; and toward the lower jaw it is deeply imbedded in the submaxillary salivary gland. The *facial portion* begins at the base of the lower jaw directly in front of the Masseter muscle.

The artery passes upward and forward on the face, at first between the Masseter and Depressor Anguli Oris muscles, afterward beneath the Zygomatic muscles and the elevators of the upper lip. It becomes superficial at the side of the nose, where it receives the name of the *lateral nasal artery.*

The branches of the Facial artery are as follows:—

Cervical Branches	(*a*) The Inferior or Ascending Palatine. (*b*) The Tonsillar. (*c*) The Glandular. (*d*) The Submental.
Facial Branches	(*e*) The Inferior Labial. (*f*) The Inferior Coronary. (*g*) The Superior Coronary. (*h*) The Angular.

(*a*) The *inferior or ascending palatine* branch ascends the neck to the outer side of the Stylo-Glossus muscle to the level of the soft palate. It sends a branch to this latter structure, to the orifice of the Eustachian tube, and to the tonsil.

(*b*) The *tonsillar* branch is the chief source of nourishment of the tonsil. When absent, its place is taken by a branch of the ascending pharyngeal artery.

(*c*) The *glandular* branches are numerous. They pass in all directions from the trunk as it is enveloped by the submaxillary salivary gland.

(*d*) The *submental* branch. This is the most important of the cervical branches. It passes forward from the median aspect of the main vessel, to supply the chin and the muscles in the supra-hyoid space. It anastomoses with the vessel of the opposite side.

(*e*) The *inferior labial* branch is inconstant. It is distributed to the skin and muscles of the chin.

(*f*) The *inferior coronary* branch often arises in common with the succeeding vessel. It supplies the lower lip, lying between the plane of the Depressor Anguli Oris and Depressor Labii Inferioris muscles to the outer side and the mucous membrane to the inner.

(*g*) The *superior coronary* branch, somewhat larger than the inferior, supplies the upper lip, occasionally sending small branches to the nose.

Both the preceding vessels anastomose with the corresponding arteries of the opposite side of the face. Hence their name, coronary arteries. This anastomosis, however, is not invariable.

(*h*) The *angular* branch. This is the terminal portion of the facial. Properly speaking, it is not a branch, but is a continuation of the lateral nasal portion of the vessel. It is situated between the internal canthus and the nose. The vessel anastomoses with the nasal branch of the ophthalmic.

The surgical bearings of the facial artery vary markedly in the cervical and facial portions of its course.—The cervical portion differs in no particular from the other cervical branches of the external carotid. It is surrounded by loose connective tissue, and is protected by the Platysma Myoides and deep fascia.—If divided just beneath the inferior maxilla, as may readily occur in the operation for excision of the latter, the cardiac end of the vessel is apt to retract into the submaxillary space.—The position of the coronary arteries with respect to the mucous membrane of the lip is important to remember. Slight wounds of the latter membrane may lacerate these vessels; Erichsen[1] mentions an instance where the hemorrhage from a slight lesion of this character had passed unnoticed until the large amount of blood swallowed had been ejected, when the wounded vessel was sought for and secured.—Portal[2] alludes to a case in which profuse hemorrhage followed the opening of a submaxillary abscess. The blood, it was thought, escaped from the submental artery.

The Ligation of the Facial Artery.—The facial artery can be exposed below the jaw by an incision similar to that for the lingual artery. The submaxillary salivary gland is the best guide to the position of the vessel. By drawing the gland slightly upward and outward, the patient's head being at the same time thrown upward and backward, the vessel can be seen lying within the line of the lower jaw upon the Mylo-Hyoid muscle.

The artery, as it passes upon the face, can be easily compressed against the lower jaw, and is readily exposed by an incision made directly in front of the anterior border of the Masseter muscle.

Variations.—The facial may interchange in part with the internal maxillary artery; the labial and submental branches may interchange among themselves. The vessel may give off the ascending pharyngeal.

[1] System of Surgery, Am. ed., p. 378.

[2] Anatomie Médicale, iii. 166.

THE OCCIPITAL ARTERY.

The Occipital artery arises from the external carotid above or about opposite to the facial. It passes upward and backward, covered by the posterior belly of the Digastric and by the Stylo-Hyoid muscle as far as the mastoid process of the temporal bone. It here runs along a groove behind the digastric groove. It lies beneath the muscles inserted into the mastoid process, and above the Superior Oblique and Complexus muscles. Toward its termination it becomes superficial, and reaches the occiput by passing through the Trapezius muscle. It is distributed to the scalp, anastomosing with its fellow of the opposite side and with the temporal arteries.

Branches.—The branches of the occipital artery are—

(*a*) Muscular.
(*b*) Auricular.
(*c*) Descending Cervical.
(*d*) Mastoid.

(*a*) The *muscular* branches supply the posterior belly of the Digastric, the Stylo-Hyoid, and the Sterno-Cleido-Mastoid muscles. One of them may give origin to the stylo-mastoid artery.

(*b*) The *auricular* branch. This is an inconstant branch supplying the auricle and the muscles inserted into the mastoid process.

(*c*) The *descending cervical* branch (ramus cervicis princeps). This arises under the Splenius muscle. It passes down the neck to anastomose with the superficial and deep cervical arteries.

(*d*) The *mastoid* branch enters the mastoid foramen to supply the diploë, and also sends branches to the walls of the lateral sinus and the dura mater of the occipital fossa.

Variations.—The occipital artery may arise from a trunk in common with the facial. It may give off an accessory pharyngeal branch. It may interchange with the deep cervical branch of the subclavian, and anastomose at the occiput with the vertebral artery.

The Ligation of the Occipital Artery.—The occipital artery, as it passes from its origin to the occiput, is deeply situated beneath the Sterno-Cleido-Mastoid muscle. An incision three inches in length, corresponding to the upper anterior margin of this muscle, will expose the artery as it crosses the internal carotid artery and the internal jugular vein. The parotid gland and its fascia should be drawn well forward and upward. The Stylo-Hyoid and the poste-

rior belly of the Digastric muscle will serve as guides to the position of the vessel at the bottom of the wound.

Upon the occiput the artery can be reached by an incision two inches long, extending backward from the position of the mastoid process. The artery becomes superficial along this line, and can be found lying beneath the aponeurotic fibres which extend from the insertion of the Sterno-Cleido-Mastoid muscle. At a deeper point between the Splenius and the Complexus muscles the artery is more difficult to secure. In the absence of a more definite guide, its pulsation against the occipital bone will serve to indicate its position.

THE POSTERIOR AURICULAR ARTERY.

The Posterior Auricular artery arises from the external carotid, nearly opposite the apex of the styloid process. It at first rests upon the latter structure, and then, penetrating the parotid gland, it becomes superficial between the auricle and the mastoid process. It ascends the side of the head between these structures, supplying the auricle, and anastomosing by its terminal branches with the temporal and occipital arteries.

The branches of the artery are—

(*a*) Stylo-mastoid.
(*b*) Auricular.

(*a*) The *stylo-mastoid* branch enters the foramen of the same name to reach the tympanum. It anastomoses with the tympanic branch of the internal maxillary artery, and supplies the chamber of the tympanum and the tympanic membrane. Twigs supply the mastoid cells.

(*b*) The *auricular* branches are commonly two in number, an anterior to supply the auricle, and a posterior to anastomose with the occipital and temporal arteries, and to give branches to the skin over the mastoid process.

Variations.—The posterior auricular may give off the transverse facial, send a large branch to the occiput, and an encranial branch to the dura mater through the stylo-mastoid foramen.

THE TEMPORAL ARTERY.

The Temporal artery arises behind the neck of the inferior maxilla, or between it and the auricle. It ascends vertically in the retromaxillary space, is surrounded by the lobules of the deep portion of the parotid gland, and, passing over the zygomatic arch to the region of the temple, lies between the skin and the superficial fascia. At a point about an inch above the zygoma it divides into two terminal branches, the anterior and posterior temporal arteries.

The branches of the temporal are—

(*a*) Glandular.
(*b*) Muscular.
(*c*) Auricular.
(*d*) Transverse Facial.
(*e*) Middle Temporal.
(*f*) Anterior Temporal.
(*g*) Posterior Temporal.

(*a*) The *glandular* branches comprise several small twigs for the parotid gland.

(*b*) The *muscular* branches are two or three small branches for the Masseter muscle.

(*c*) The *auricular* branches supply the anterior portion of the auricle.

(*d*) The *transverse facial* branch passes directly forward within the substance of the parotid gland, over the parotid duct, or between it and the zygoma and Masseter muscle. It aids in supplying the superficies of the face (including the Orbicularis Palpebrarum, Zygomatici, and Levator Anguli Oris muscles), and anastomoses with the facial, buccal, and infra-orbital branches of the internal maxillary arteries.

(*e*) The *middle temporal* branch pierces the deep temporal fascia to give branches to the Temporal muscle. It often sends an anterior (orbital) branch to the Orbicularis Palpebrarum muscle.

(*f*) The *anterior temporal* branch, larger and more tortuous than the posterior, passes obliquely forward and upward over the deep temporal fascia, supplying branches to the anterior portion of the superficies of the temporal region. It anastomoses with the facial, frontal, and posterior temporal arteries.

(*g*) The *posterior temporal*, smaller and straighter than the anterior, passes upward toward the vertex of the skull. It anastomoses with the occipital, the posterior auricular, and the anterior temporal.

Variations.—The temporal artery in part interchanges with the internal maxillary. It sends an occasional small encranial branch to join the great meningeal artery. The transverse facial may infrequently be of increased size; notably in connection with imperfect development of the facial. Under the name of the *zygomatico-orbitalis*, a branch has been described which occasionally arises from the main trunk of the temporal immediately after it passes over the zygomatic arch. It passes forward toward the upper margin of the orbit, where it anastomoses with the lachrymal, frontal, and anterior temporal arteries.—The temporal artery is very tortuous in aged persons.

Arteriotomy.—The practice of opening the temporal artery to relieve congested conditions in the temporal region and orbit is well sustained on anatomical grounds. It has been seen that the anastomoses with branches of the internal maxillary and ophthalmic artery are decided. The blood supply

of the outer portion of the orbit is subject to much variation. The lachrymal gland and the parts adjacent are apt to derive much of their blood supply from the terminal branches of the external carotid artery.

Hence the "temporal pulse," or the pulsation of the anterior temporal artery, is of great importance in ascertaining the degree of vascular turgescence of the orbital contents. In both intra-ocular and peri-ocular pressure the pulse is tense and bounding. The practice of opening the artery has been superseded of late by leeching and deep scarification, and by the use of the artificial leech. Should it be deemed advisable to open the vessel, it is important to bear in mind that, while it is readily compressed over the zygomatic arch, it would be inadvisable to attempt its division at that place, since the retraction of the divided ends has been followed by hemorrhage and abscess. Mr. Harrison narrates a case in which varicose aneurism followed such practice. The anterior branch should in all cases be selected.

Ligation of the Temporal Artery.—A vertical incision one inch in length above the zygoma and near the ear will be in the line of the position of this artery. Division of the temporal aponeurosis is next necessary, with careful isolation of the vessel from the small twigs of temporal nerves.

The temporal artery, as it lies imbedded in the parotid gland, becomes an important vessel in operations upon the gland. Owing to its deep position, and its varied and important surroundings at this point, the vessel is never here exposed with a view to its separate ligation.

THE INTERNAL MAXILLARY ARTERY.

This is the largest of the branches of the external carotid. It arises behind the parotid gland, and passes forward in a tortuous manner to supply, for the most part, the deeper structures of the facial region. It is, from this fact, often called the deep facial artery.

It is customary to divide the artery for description into three portions:—

1st, that which lies behind the neck of the inferior maxilla.

2d, that which traverses the interval between the neck and the superior maxilla.

3d, that which lies within the region of the superior maxilla.

The branches of the artery are as follows:—

1st portion (branches passing through osseous openings).	(*a*) Tympanic. (*b*) Middle or Great Meningeal. (*c*) Small Meningeal. (*d*) Inferior Dental.
2d portion (branches not passing through osseous openings).	(*e*) Deep Temporal. (*f*) Pterygoid. (*g*) Masseteric. (*h*) Buccal.
3d portion (branches again passing through osseous openings).	(*i*) Alveolar or Superior Maxillary branch. (*j*) Infra-Orbital. (*k*) Descending or Superior Palatine. (*l*) Vidian. (*m*) Pterygo-Palatine. (*n*) Nasal or Spheno-Palatine.

(*a*) The *tympanic* branch enters the chamber of the tympanum through the fissure of Glaser, and supplies the membrane of the tympanum. It supplies the Laxator Tympani, and anastomoses with the stylo-mastoid branch and with the Vidian arteries.

(*b*) The *middle, or great meningeal* branch, ascends obliquely to the base of the skull, through a loop of the auriculo-temporal nerve, entering the spinous foramen of the sphenoid bone to be received in a groove upon the inner surface of the greater wing. From this point it ascends the lateral wall of the cranium in a series of divergent grooves which range chiefly upward and backward upon the inner surface of the parietal bone. The artery supplies the dura mater and the diploë. Minute branches pass to the lachrymal gland, to the ganglion of the fifth pair of nerves, and through the hiatus Fallopii, beyond which they anastomose with the stylo-mastoid branch of the posterior auricular artery. Before entering the skull the arteries send small branches to the Pterygoid muscles and adjacent parts.

The great meningeal artery may supply the lachrymal gland to the exclusion of the ophthalmic. In rare instances, where the latter artery is absent, the great meningeal supplies its place. Quain gives an example in which deficiency of the internal carotoid had resulted in two tortuous branches from the internal maxillary, which entered the skull by the foramen rotundum and foramen ovale to supply its place.

Rarely branches of the encranial portion of the artery, according to Hyrtl,[1] will perforate the wall of the skull, and anastomose with the deep temporal branches of the main trunk.

The grooves receiving the terminal portions of the artery are often at intervals converted into bony canals. In diseased conditions this tendency is exaggerated. The distribution of ostitis dependent upon constitutional causes, such as syphilis and scrofula, is frequently determined in the skull by the course of this vessel within the sphenoid and parietal bones.

The intimate relations existing between this vessel and the diploë afford an easy explanation of the occurrence of compression of the brain after the reception of blows upon the side of the head. According to Mr. Prescott Hewett,[2] out of thirty-one cases of fracture of the skull, accompanied by extensive extravasation, the blood had proceeded from the

[1] Oesterr. Zeit. für prakt. Heilkunde, 1859, Nos. 9, 30, 39.

[2] Holmes's System of Surgery, ii. 106.

great meningeal in twenty-seven cases. In the language of the same writer, "The spot usually referred to in extravasation of blood from the middle meningeal artery is the antero-inferior angle of the parietal bone; but extensive extravasations may occur from this vessel or some of its branches over pretty nearly the whole of the lateral surface of the skull. In fractures involving the middle fossa, the most common of all the fractures of the base of the skull, this vessel may be torn across in any part of its course between the foramen spinosum and the antero-inferior angle of the parietal. And in the middle fossa of the skull, it frequently happens that the middle meningeal artery divides into two large branches of equal size, one proceeding to the antero-inferior edge of the parietal, and the other passing much more posteriorly, and sending large ramifications over the whole of the parietal and corresponding parts of the frontal and occipital bones. A fracture running across any of these large branches may give rise to an extensive extravasation of blood."

Aneurismal tumors have rarely been found upon the artery as it lies within the groove of the parietal bone.

(*c*) The *small meningeal artery* (meningea parva) often arises from the preceding. It enters the cranium through the foramen ovale, and supplies the dura mater of the middle cerebral fossa and the ganglion of the fifth cranial nerve.

(*d*) The *inferior dental* branch arises from the main trunk opposite the middle meningeal. It passes obliquely downward and forward between the internal lateral ligament and the neck of the lower jaw to the posterior dental foramen, through which it enters the inferior dental canal in company with the inferior dental nerve. At the position of the mental foramen it divides into its terminal branches. One branch effects its exit at the foramen to supply the adjacent soft parts, and to anastomose with the facial; the other continues within the cancelli of the lower jaw as far as the symphysis. The main trunk, while within the dental canal, gives off numerous minute branches for the supply of the bone and teeth; the latter twigs penetrating the foramina at the tips of the roots of the teeth.

Before entering the inferior dental canal the artery gives off the *mylo-hyoid* branch, which runs along the groove of the same name in company with the mylo-hyoid nerve. It supplies the Mylo-Hyoid muscle and the mucous membrane of the mouth.

(*e*) The *deep temporal* branches. These are two in number, the anterior and the posterior. The posterior ascends between the Pterygoid muscles to the lower part of the Temporal muscle, as it arises from the temporal fossa.

The anterior deep temporal ascends in the anterior or sphenoid portion of the temporal fossa. It commonly perforates the orbital septum to reach the lachrymal gland.

Both deep temporal arteries supply chiefly the Temporal muscle, occasionally aiding in nourishing the diploë.

(*f*) The *pterygoid* branches, as the name implies, go to the Pterygoid muscles.

(*g*) The *masseteric* branch passes outward through the sigmoid notch to reach the Masseter muscle. It anastomoses with the transverse facial artery. Velpeau[1] asserts that this vessel is necessarily compressed and possibly ruptured in dislocation of the jaw.

(*h*) The *buccal* branch passes forward to the tissues of the cheek in company with the buccal nerve. After supplying the Buccinator muscle and mucous membrane of the cheek, it pierces the former to anastomose with the transverse facial.

(*i*) The *alveolar* or *superior maxillary* branch. This artery often arises in common with the infra-orbital. It descends upon the tuberosity of the superior maxilla, and enters special canals to reach the roots of the molar and bicuspid teeth. It also supplies the mucous membrane of the maxillary sinus, and the gum.

(*j*) The *infra-orbital* branch passes forward in company with and above the infra-orbital nerve. It traverses the entire length of the infra-orbital canal, and terminates at the infra-orbital foramen by two small twigs, an ascending and a descending branch. The ascending branch supplies the lachrymal sac and adjacent structures, anastomosing with peripheral twigs of the facial and ophthalmic arteries. The descending branch lies upon the Levator Anguli Oris, and anastomoses with the facial artery.

The artery in the canal sends important branches to the front teeth and lining membrane of the maxillary sinus. It also sends small branches upward to supply the Inferior Rectus and the Inferior Oblique muscles of the eye.

(*k*) The *descending palatine* branch descends in the posterior palatine canal to the hard palate. It passes horizontally forward along the lateral aspect of the hard palate, grooving the bone, to the incisive foramen, in which it terminates by anastomosis with the nasal branch. It supplies the gum-tissue of the upper jaw, hard palate, and alveoli. Within the posterior palatine canal it commonly sends a small branch to the mucous lining of the nasal chamber. It anastomoses with the pharyngeal branch of the facial, or, in the absence of this branch, it sends a posterior division to the site of the pharynx, tonsil, and velum palati. This distribution is given as the normal one by most German authors.

[1] Chir. Anat., i. 90.

(*l*) The *Vidian* branch enters the canal of the same name to supply the upper part of the pharynx, the orifice of the Eustachian tube, and the Levator Palati muscles. It anastomoses with the ascending pharyngeal and stylo-mastoid arteries.

(*m*) The *pterygo-palatine* branch is often a branch of the spheno-palatine. It enters the canal of the same name to supply the sphenoial cells and adjacent portion of the pharynx near the posterior nares.

(*n*) The *nasal* or *spheno-palatine* branch is the terminal branch of the internal maxillary artery. It enters the nasal chamber by the spheno-palatine foramen. The main branches supply the septum of the nose, the maxillary sinus, and the turbinated bones, and anastomose anteriorly with the terminal branches of the posterior palatine artery.

Remarks.—Cheselden narrates a case of fatal hemorrhage in excision of the tonsil, attributed to the division of a branch of the internal maxillary artery.[1]

The artery was divided by Shuh[2] in attempting a division of the fifth nerve for neuralgia. The accident necessitated the ligation of the internal carotid artery. Death from septicæmia ensued at the end of the fourth month.

An aneurism of the artery may form a tumor in the region of the temple. A case is on record of this affection occurring in a young woman. A knife was thrust into the swelling by the medical attendant, who mistook it for an abscess.[3]—A. C. Castle[4] has recorded an example of an aneurism of the descending palatine branch. Forming a conspicuous swelling on the hard palate, the tumor was incautiously opened, when a quantity of blood escaped sufficient to fill at once the mouth and throat of the patient. After plugging the wound with cork, the hemorrhage was permanently controlled.

Variations.—The branches of the artery, viewed as a whole, interchange in part with the facial, the lingual, the ophthalmic, and the temporal arteries.—The encranial branches are often in excess, and may interchange with the internal carotid artery of the same side; partial parallelism exists between the varieties of the veins and arteries about the temporal bone. See an account of the connection between the development of the brain and the disposition of the primitive venous trunks of the embryo under descriptions of the Veins.

THE ASCENDING PHARYNGEAL ARTERY.

This small vessel arises from the external carotid near the origin of the internal carotid. It ascends toward the base of the skull between the internal surface of the Internal Pterygoid muscle and the posterior wall of the pharynx. After supplying these structures and the deep lymphatic glands it anastomoses with the descending cervical artery. It also yields small inconstant branches to the superior cervical sympathetic ganglion, and to the dura mater through the anterior condyloid foramen.

Remarks.—W. M. Baker[1] records a case of a female who fell to the ground while holding a tobacco-pipe in her mouth. Some swelling of the throat followed. On the fourth day a hemorrhage occurred through the mouth, which recurred the following day, death taking place the same evening. At the post-mortem examination a wound was found in the side of the oro-pharynx, and it was concluded that the bleeding had taken place from the opening made in the ascending pharyngeal artery at the time of the fall. The internal carotid artery was uninjured.

The furious bleeding which sometimes occurs after the removal of an enlarged tonsil by the knife is supposed to arise from the terminal twigs of the ascending pharyngeal artery, or from a free arterio-venous anastomosis of exceptional character.

Variations.—The ascending pharyngeal may interchange with branches from the facial, the lingual, and the occipital arteries. It may penetrate the base of the skull, and supply the walls of the cavernous sinus.

THE INTERNAL CAROTID.

The Internal Carotid Artery (figs. 2 and 3, Plate LXIII.; figs. 2 and 3, Plate LXIV.) is the axial continuation of the common carotid. Together with its branches it supplies the brain, the orbit, the region of the forehead, and in part the nasal chamber and the external nose.

It begins on the level of the upper border of the thyroid body, and ascends the neck nearly vertically, with a slight curve, to the under surface of the petrous portion of the temporal bone, where it enters the carotid canal. Directly after its entrance the artery is directed abruptly forward and inward, to become again vertical as it escapes from the inner end of the carotid canal over the tissue occupying the foramen lacerum medium. It is now received within the cavernous sinus, and lies in the groove on the outer side of the body of the sphenoid bone. For the third time it assumes a vertical position, and pierces the dura mater near the anterior clinoid process behind the optic foramen, there to divide into its branches. The artery thus has five windings or curves. To these Portal adds a sixth, where the vessel lies over the foramen lacerum medium.

Relations.—The internal carotid artery takes its origin at a point where the cervical relationships are becoming

[1] Portal, Anat. Med. iii. 183.
[2] Rosenthal's Anatomie, ii. 209.
[3] Archives Générales de Médecine, xvii. 593.
[4] Lancet, 1850, vol. ii. 15.

[1] St. Bartholomew's Hosp. Rep. 1876, 163.

complicated by the proximity of the lower jaw, and the submaxillary region. It lies on the slips of origin of the Longus Colli muscle, and on the transverse processes of the three upper cervical vertebræ. Behind it are the superior cervical ganglion, the internal jugular vein, and the pneumogastric nerve. Near its origin the artery is covered by the inner margin of the Sterno-Cleido-Mastoid muscle, the Platysma-Myoides muscle, and fascia. These relations are the same as those of the common carotid. It is soon removed from the surface by important structures crossing it obliquely to or from the submaxillary region; the occipital and the posterior auricular arteries passing outward, while the hypo-glossal and the glosso-pharyngeal nerves, the Digastric, the Stylo-Hyoid, the Stylo-Glossus, and the Stylo-Pharyngeus muscles pass inward. The artery lies near the lateral wall of the pharynx above the outer side of the tonsil. The ascending pharyngeal artery lies as a rule beneath it and to the inner side. The external carotid vessel is usually placed on its inner side with the Stylo-Glossus and the Stylo-Pharyngeus muscles, and with a portion of the parotid gland.

The internal carotid artery is on a plane more superficial than the external, and it may be in front of the latter. Slight inward deflection of the internal carotid will place the trunks of these two vessels at an acute angle. In the course of operations upon the neck the two trunks have been from this cause occasionally confounded. By separating the suspected vessel from its surroundings for a short distance, the many-branched external carotid will enable the operator easily to distinguish it from the branchless internal carotid.

The internal carotid artery has on either side a filament of the sympathetic nerve derived from the superior cervical ganglion; the two filaments unite with others over the artery to constitute the carotid plexus which enters the carotid canal with the artery.

Within the cavernous sinus the artery lies to the inner side, and is covered by a layer of the dura mater which passes a short distance within the carotid canal. The third, fourth, and sixth nerves, and the ophthalmic branch of the fifth nerve, lie to its outer side.

Remarks.—The internal carotid artery in the *neck* is occasionally tortuous just before entering the carotid canal, or, as the result of obstruction in the cerebral circulation at and after middle age, the internal carotid artery may undergo dilatation. The dilated portion is usually about three-fourths of an inch in length, and invariably involves the first part of the vessel, and sometimes the common carotid at the point of division, the remaining portion of the vessel having a normal appearance. Since it is not found in infancy, the dilatation may be assumed to be an acquired condition.

The relations which exist between the degrees of tortuosity, or dilatation or division of the internal carotid in the neck, should always be studied in connection with the bloodvessel supply of the thyroid body. Observers have generally been of the opinion that the thyroid body served as a diverticulum to the current of blood ascending the neck to the head. A connection could probably be established between the calibre of the vessel before entering the carotid canal and the condition of the thyroid body, since anomalies of this body are often associated with irregularity of the common carotid and vertebral arteries. It has been estimated by Luschka that the sum of the transverse sections of the thyroid arteries equals the sectional area of the internal carotid artery of the same side, so that through the four arteries supplying the thyroid body nearly as much blood passes as goes to supply the brain through the vertebral and internal carotid arteries.

The vessel may divide into two terminal branches within the cavernous sinus, but these rarely correspond to an equal number of openings in the dura mater.

Some of the most important relations of the internal carotid artery in the neck are with the pharynx. It has been seen that the vessel lies directly to the outer side of the tonsil. Incautious lancing of this body has been known to open the internal carotid, as is narrated by Béclard.[1] Similar lesions have followed upon wounds from fragments of pipes, etc.

Sloughing of the lymphatic gland beneath and behind the inferior maxilla has also been known to cause hemorrhage from the upper portion of the trunk. Mr. Jas. Nicholls[2] met with this lesion in a girl fourteen years of age, convalescent from scarlet fever.

Notwithstanding the depth at which the internal carotid artery lies, it may be exposed along its entire length by lacerated wounds of the upper part of the neck. This statement receives confirmation from a case recorded by Dr. A. Twitchell.[3] A young man, aged twenty, was wounded by the wadding of a pistol discharge. The wound involved the parotid gland, the Temporal, Masseter, and Pterygoid muscles, and, besides fracturing the superior maxilla, severed the external carotid artery and penetrated the larynx. The internal carotid artery was exposed from near the bifurcation of the common trunk to the point where it curved to enter the canal in the petrous portion of the temporal bone. The vessel ulcerated. The common carotid was ligated and the patient recovered.

The relations of the internal carotid artery in the *head*, and particularly at the base of the skull, as

[1] Blandin, Anatomie Topographique, 89.
[2] St George's Hosp. Rep., iv. 1869, 211.
[3] N. Y. Journ. Med. 1857, 13, paper by Jas. R. Wood.

the vessel enters it through the carotid canal, are of great importance in studying aneurism of this vessel. The sac has been known to press the optic nerve downward and stretch its fibres, to absorb the body of the sphenoid bone, and to create a cavity within the anterior perforated space of the cerebrum of its own side, as well as to obliterate the adjoining roots of the corresponding olfactory nerve and the anterior part of the corpus striatum.[1] In other instances the effects of the pressure have been most evident in the cavernous sinus, and upon the ganglion of the fifth nerve.[2] The symptoms created by the above lines of pressure are as follows: Pressure on the optic nerve will induce blindness; on the cavernous sinus, venous stasis in the orbit, œdema of the eyelids, and optic neuritis. Pressure on the nerves passing through the cavernous sinus or in its outer wall will, if slight, affect the sixth only (since this of all the cranial nerves is the most exposed), when the External Rectus muscle will be paralyzed and internal strabismus will follow. If the pressure prove excessive, the third and even the fourth nerves will suffer, with consequent paralysis of the remaining periocular muscles, together with dilatation of the pupil or sloughing of the cornea. It may be expected, therefore, as a result of aneurism of the terminal portion of the internal carotid artery, that the case will include one or more of the following symptoms: neuralgia, referable to the fifth nerve, corneal sloughing, ptosis, fixation of the eyeball or converging strabismus, and amaurosis.

Tumors, other than those of an aneurismal nature, may also compress the internal carotid at the base of the skull. Among these may be mentioned growths originating in the body of the sphenoid bone, in the pituitary body, and in the cavernous sinus.[3] Pollock found the artery, in fracture of the skull in a male, ruptured nearly one-half of its circumference, at a point a little beyond the carotid groove of the sphenoid bone.

Under the head of the temporal bone, instances of fatal hemorrhage, excited by the laceration attending the removal of the necrosed bone, have been cited. When the relations of the temporal bone to the artery are considered, such a lesion would appear to be inevitable.

The proximity of the trunk of the internal carotid artery to the ear has induced aurists to seek for the cause of one form of *tinnitus aurium* in the conduction of the pulsations of this vessel directly to the auditory nerve. The internal jugular vein, a small artery occasionally passing through the stapes, and even the posterior auricular branch of the external carotid, have been held by various observers to cause similar vascular murmurs; and, while no proof has been presented to show that such may be the case, it is highly probable that under abnormal conditions noises may be transmitted to the ear from the vessels in its neighborhood.

[1] Mr. Moore, Tr. Path. Soc. London, i. 243.

[2] Jas. Adams, Lancet, Dec. 1869, 769. M. H. Romberg, Neural. Nervi Quinti specimen, Berlin, 1840, fig.

[3] Virchow's Archiv, 1876.

Variations.—The branches of the internal carotid artery in the neck may interchange in part with the superior laryngeal, the ascending pharyngeal, the occipital, and the transverse facial branch of the temporal. The encranial branches may interchange among themselves, and a separate encranial branch may anastomose with a branch of the posterior auricular and the internal maxillary arteries.

The branches of the internal carotid artery are—

(*a*) The Tympanic.
(*b*) The Branches to the Dura Mater.
(*c*) The Ophthalmic.
(*d*) The Anterior Cerebral.
(*e*) The Anterior Communicating.
(*f*) The Middle Cerebral.
(*g*) The Posterior Communicating.
(*h*) The Choroid.
(*i*) The Anterior Choroid.

(*a*) The *tympanic* arises from the carotid artery as it lies within the carotid canal. It is a minute twig, which pierces the roof of the canal, and supplies the membrane of the tympanum. It anastomoses with the stylo-mastoid, Vidian, and tympanic branches of the internal maxillary artery.

(*b*) The *branches to the dura mater*. Within the cavernous sinus a small vessel supplies the dura mater defining the sinus. In addition it sends twigs to the dura mater about the pituitary fossa, the pituitary body, and the ganglion of the fifth nerve. A twig passes to the tentorium, and anastomoses in the middle cerebral fossa with the great meningeal artery.

J. Sapolini[1] proposes for the branches of the twig supplying the region of the pituitary fossa the name of the *rayed arteries* (artères rayonnées). One twig passes along the pathetic nerve, and one to the basilar process.

Duret found the internal carotid furnishing minute branches to the optic chasm at its outer border. It may rarely send two twigs to the striated body, which it reaches through the anterior perforated space.

[1] L'Aire de la Selle Turcique, Brussels, 1880, 46, fig.

Portal[1] asserts that a minute artery pierces the internal auditory canal to reach the tympanum; a *second* enters the posterior orifice of the pterygoid canal to anastomose with the pterygoid artery; a *third* ascends to the cranium through the sphenoidal foramen after having given a branch which accompanies the branch of the nerve which unites the sympathetic with the pathetic, and after having furnished various branches to the dura mater. Other twigs anastomose with the recurrent branches of the ophthalmic artery.

The ascending pharyngeal and occipital arteries are occasionally given off from the internal carotid.

(*c*) The *ophthalmic artery*. The ophthalmic artery arises from the internal carotid just before it divides into the anterior and the middle cerebral. It takes its origin from the last curve of the vessel directly after it has pierced the dura mater, on a level with the anterior clinoid process of the sphenoid bone. It lies over the cavernous sinus at the base of the skull, and enters the orbit through the optic foramen, beneath and to the outer side of the nerve, but within its sheath. Soon after entering the orbit it escapes from the sheath, and crosses the nerve obliquely to get to the inner wall of the orbit, along which it passes between the Internal Rectus and Superior Oblique muscles to the trochlear process where it terminates by division into the frontal and nasal branches.

The ophthalmic artery gives off the following branches:—

(1) Lachrymal.
(2) Posterior ciliary.
(3) Supra-orbital.
(4) Central retinal.
(5) Posterior ethmoidal.
(6) Anterior ethmoidal.
(7) Palpebral.
(8) Muscular.
(9) Frontal.
(10) Nasal.

(1) The *lachrymal artery*, the largest branch of the ophthalmic, passes along the outer wall of the orbit, above the External Rectus muscle to the lachrymal gland, to which it gives numerous branches, and escapes upon the upper eyelid to terminate in the external palpebral. The lachrymal, not far from its origin, sends a recurrent branch through the anterior lacerated foramen to the dura mater to anastomose with the middle meningeal artery. The malar foramina convey other branches to the temporal fossa and the face. The lachrymal artery also sends branches to the periosteum of the outer wall of the orbit, to the External and Superior Rectus, and to the Levator Palpebræ.

(2) The *posterior ciliary branches*. These are divided into a short and a long set.

The vessels of the short set, varying from four to ten in number, arise from the main artery as it crosses the optic nerve, and pursue a tortuous, somewhat spiral course forward through the fat surrounding the optic nerve to pierce the sclerotic coat about the point at which the nerve effects its entrance. They are distributed to the choroid coat. The vessels of the long set are two in number. They penetrate the sclerotic coat near the preceding on either side of the eyeball between the sclerotic and choroid coats as far as the ciliary ligament, where each divides into two branches, an upper and a lower. These branches, uniting with the corresponding twigs of the opposite side, constitute a circle from which the iris receives its blood.

(3) The *supra-orbital branch* passes forward, between the roof of the orbit and the elevator of the lids, to the supra-orbital foramen, within which it sends a small branch to the diploë of the frontal bone. It then divides into a superior and a deep branch; the former, the larger of the two, goes to the Occipito-Frontalis muscle and to the integument; the latter to the periosteum of the frontal bone.

(4) The *central retinal artery*. This minute vessel arises from the ophthalmic artery. It enters the optic nerve obliquely from beneath, and passes along the centre of the nerve to enter the eyeball. It supplies the retina and the hyaloid membrane. In the fœtus the vessel is prolonged through the centre of the vitreous humor, and is lost upon the posterior capsule of the lens.

(5) The *posterior ethmoidal branch* is of variable size. It passes to the inner wall of the orbit, and enters the

[1] Anatomie Médicale.

EXPLANATION OF PLATE LXIV.

Fig. 1. A section of the cerebrum, showing the position of the choroid plexus.

Fig. 2. The ophthalmic artery and its branches.

Fig. 3. The circle of Willis. The anterior communicating artery has been represented many times too wide.

Fig. 1

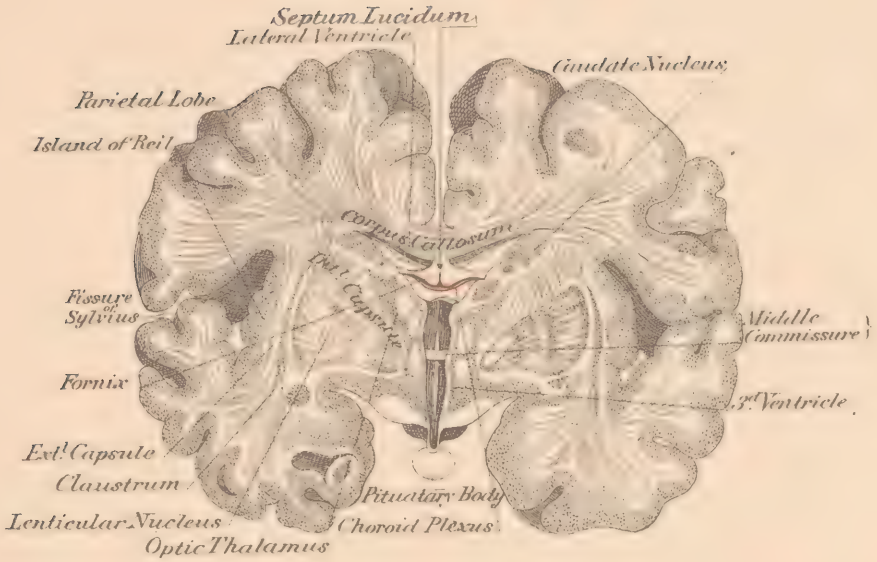


Fig. 2

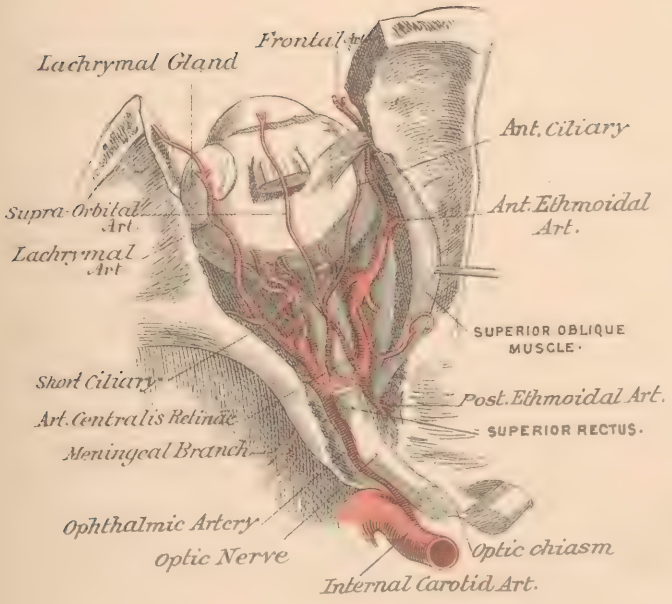
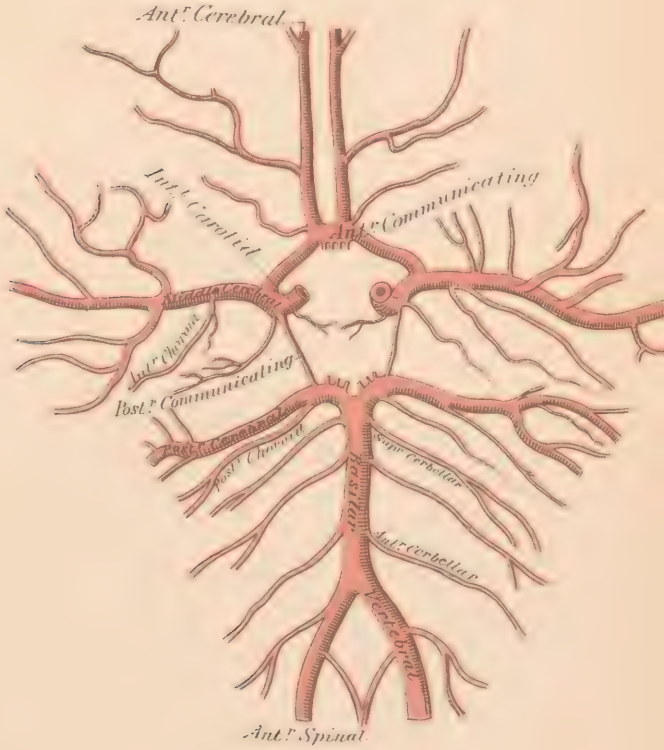


Fig. 3



T. Sinclair & Son Lith.

posterior ethmoidal foramen to supply the posterior ethmoidal cells and the dura mater.

(6) The *anterior ethmoidal branch* is generally larger than the preceding. It enters the anterior ethmoidal foramen, and passes, in company with the nasal nerve, through the anterior foramen of the cribriform plate, to the nose. It supplies a branch to the superior and middle turbinated bones and a small twig to the roof of the nasal chamber and the septum, where it anastomoses with the spheno-palatine artery.

(7) The *palpebral arteries.* These are the terminal twigs of the main trunk, and supply both upper and lower lids, the tarsal cartilages and glands. The external palpebral and internal palpebral twigs anastomose one with another.

(8) *Muscular branches.* In addition to those already described as branches of the lachrymal, twigs arise from the main trunk which are distributed to the inner, superior, and inferior periocular muscles.

(9) The *frontal artery* winds round the inner edge of the supra-orbital margin of the orbit, furnishes branches to the inner part of the upper lids, and divides into branches which are lost beneath the skin of the lid and the forehead. A few twigs are distributed to the nasal slip of the Occipito-Frontalis muscle.

(10) The *nasal branch* pierces the Orbicularis Palpebrarum over the internal palpebral ligament, and passes down along the root of the nose to anastomose with the terminal angular branch of the facial. Occasionally a vessel is seen crossing the bridge of the nose to join the vessel of the same name of the opposite side. Branches also go to the lachrymal sac and canal, to the lachrymal caruncle, and to the origin of the Orbicularis Palpebrarum.

The ophthalmic artery with its field of distribution has been compared to a cone whose general figure answers to that of the orbit, and which retains the central retinal artery as an axis. In reviewing its branches, it is seen that distinct branches are reserved to the eyeball and its appendages. Important anastomoses are observed at the root of the nose, between branches of the external carotid, the facial and the nasal, the ethmoidal, and the spheno-palatine arteries.

It appears never to anastomose with the anterior or the middle cerebral artery.

Nunneley[1] has described an example of aneurism affecting the encranial portion of the artery.

The ophthalmic artery may effect an important anastomosis with the middle meningeal, and in a measure interchange with this vessel. In orbital aneurism it is probable, therefore, that branches of the middle meningeal would be found enlarged.

[1] Trans. Path. Soc. 1860, xi. 8, fig.

(*d*) *The anterior cerebral artery.* The anterior cerebral artery arises from the carotid, nearly at a right angle to that vessel, and forms with the middle cerebral an obtuse angle open forward and outward, and directed toward the rostrum of the corpus callosum. After curving forward round the anterior extremity of this body, near and parallel to the corresponding artery of the opposite side, it divides into three or four branches which supply the frontal lobe, the parietal lobe as it appears within the longitudinal fissure, and the corpus callosum.

In addition to this distribution, the vessel supplies the optic nerve of the same side, the rostrum as well as the main portion of the corpus callosum, and the caudate nucleus. The supply of the latter may, however, be derived from the middle cerebral artery. The terminal twigs may supply the pineal gland, and even reach the posterior cerebral commissure.

Aneurism, at the basal portion of the artery, pressing upon the seventh nerve, has been reported by Durand and J. W. Ogle.[1]

(*e*) *The anterior communicating artery.* The anterior communicating artery unites the two anterior cerebral arteries. It is situated beneath the rostrum of the corpus callosum, a short distance in front of the optic chiasm. Sometimes there are two arteries in this position, one of normal size, the other smaller. The communicating artery furnishes branches to the gray layer in connection with the optic chiasm, to the rostrum of the corpus callosum, and often one or two larger branches perforating the latter to the anterior pillars of the fornix, the anterior commissure, and the septal area.

(*f*) *The middle cerebral artery.* The middle cerebral artery, the largest branch of the internal carotid, divides into four branches on the island of Reil. Commonly the first of these is detached from the others, and supplies the orbital region at its outer part and the inferior frontal convolution. The second branch supplies the middle frontal convolution posteriorly, while the third passes by means of the fissure of Rolando to the upper part of the ascending frontal and ascending parietal convolutions. The fourth is limited to the posterior division of the fissure of Sylvius, to both sides of which it gives branches, above to the inferior frontal and below to the superior spheno-temporal convolution. The artery, in addition, sends numerous minute twigs through the anterior perforated space to supply the striated body and associated parts.

[1] Med.-Chir. Trans., xlii. 407.

An embolus entering the internal carotid is naturally carried toward the middle cerebral, since this trunk is the larger of the two as well as a direct upward continuation of the carotid stem.

A detailed Account of the Minute Branches of the Middle Cerebral Artery.—These are among the most numerous of the arteries penetrating the brain substance, and, by reason of grave brain-lesions being frequently associated with them, are of great importance in the study of practical medicine. In common with other arteries of their kind they are isolated from one another even to the ultimate twigs of a single vessel. Thus the effects of their lesions will be often strictly limited.

Immediately after the origin of the main trunk from the internal carotid a number of minute branches pass at right angles through the anterior perforated space to supply the basal ganglia, but more particularly the striated bodies. These vessels are arranged in three groups, as follows:—

1st. A group composed of those twigs which supply the ventricular aspect of the striated body through the caudate nucleus. They are called the *internal lenticulo-striated* or internal arteries.

2d. A group composed of branches passing upward into the outer portion of the lenticular nucleus, near the external capsule, the claustrum, and the island of Reil. These traverse the base of the corona radiata, and end in the head of the caudate nucleus, and are called the *lateral* (external) arteries of the striated body, or the *external lenticulo-striated* arteries.

3d. A group of branches resembling the preceding in their general direction, but supplying the posterior part of the lenticular nucleus, the anterior part of the optic thalamus, and the contiguous internal capsule. These are named the *lenticulo-optic* branches.

Hemorrhage from the first group will lacerate the caudate nucleus and the adjacent medullary substance of the anterior cerebral lobe. Perforation of the lateral ventricle may also occur. This occurrence is rare, a result in part due to the fact that the caudate nucleus has a variable blood-supply to which the anterior cerebral often contributes.—Hemorrhage from the second group, as it lies to the outer side of the lenticular nucleus, will destroy the external capsule and the claustrum, and by pressure inward will lacerate the lenticular nucleus and internal capsule.—In hemorrhage above the lenticular nucleus in the corona, a large clot commonly forms in the medullary substance, while the caudate nucleus and the anterior portion of the optic thalamus are bulged forward till they encroach upon the space of the lateral ventricle; or the clot may even protrude through the caudate nucleus into the cavity of the ventricle.—Hemorrhage from the third group will involve the tail of the caudate nucleus, and the anterior part of the optic thalamus, or the posterior part of the lenticular nucleus in connection with the foregoing. The blood may flow thence downward within the substance of the crus.

The cerebral hemispheres above the basal ganglia are, according to the researches of Duret, supplied by both medullary and cortical vessels. The *medullary* vessels are fewer in number than the cortical, but are larger, and give off numerous collateral branches. Their terminal branches reach the cortex. The *cortical* vessels represent the final distribution of the bloodvessel supply of the pia mater. They supply the claustrum, forming delicate networks of capillaries. Both sets are penicillated.

The arterial supply to the cerebrum, especially at its anterior and lateral portions, as derived from the branches of the internal carotid, is without important or constant anastomosis; thus, the peripheral surfaces of the two hemispheres are isolated, and the different portions of the same hemispheres imperfectly united. These facts are of great value in studying the results of hemorrhage or embolus in the ultimate distribution of the anterior and middle cerebral arteries.

(*g*) *The posterior communicating artery.* The posterior communicating artery lies to the outer side of the pituitary body, and completes the circle of Willis laterally by joining the posterior cerebral. To the inner side of this vessel is seen the posterior choroid which is distributed to the pineal gland and the choroid plexus. The artery may be so inconsiderable in size that it can have little influence in establishing free inosculation. In this way, according to Charcot,[1] may be explained the instances of softening of an entire central hemisphere when the terminal portion of the internal carotid is obliterated by a clot.

Minute branches are sent to the optic chiasm, the tuber cinereum, the mammillary bodies, and the optic thalamus. One of these, known as the *anterior internal artery of the optic thalamus*, passes upward to the thalamus within the third ventricle through the tuber cinereum. A second branch, the *posterior* internal, is often a branch of the posterior cerebral. It enters the thalamus on the ventricular aspect through the posterior perforated space.

[1] Leçons sur les Local. dans les Maladies du Cerveau, 1876, 50.

Relations of the Posterior Communicating Artery.

Anterior perforated space.
Optic tract.
Crus cerebri (anterior portion).

Corpora albicantia.
Sixth nerve.



Third nerve.
Anterior choroid artery.

Sub-arachnoid lymph-space.
Inner end of ridge of petrous portion of the temporal bone.

It will at once be seen from the above plan that, if an aneurismal swelling upon the posterior communicating artery extends outward, it will cause paralysis of the third nerve; if it extends inward, paralysis of the sixth nerve; and if it extends upward, disturbance of vision with hemiplegia. In each of the three cases of this aneurism collected by Durand some of the above symptoms were present.

The two vessels are frequently of unequal size, the right being commonly the larger, and in some specimens the vessel appears to be a large branch of the internal carotid equal in size to the anterior or middle cerebral. When the posterior communicating artery of one side is thus enlarged, the opposite vessel is correspondingly small.

A female of eighteen years, who was suffering from paralysis of the third nerve, died suddenly on the twenty-third day. A small ovoid aneurism was found upon the left communicating cerebral artery, near the internal carotid.[1]

(*h*) *The choroid artery.* This vessel is given off to the outer side of the preceding. It is a small vessel, which passes backward and outward along the optic tract. It sends branches to the crus cerebri, on its way to the middle horn of the lateral ventricle, which it enters at the transverse fissure, to supply the hippocampus, corpus fimbriatum, and the choroid plexus.

(*i*) *The anterior choroid artery.* The anterior choroid artery varies in origin, and is larger than the posterior communicating vessel. It is directed obliquely outward and backward between the crus and the spheno-temporal lobe of the cerebrum, along the outer side of the optic tract, and joins the choroid plexus of the lateral ventricle. It supplies the optic tract, the upper and the outer aspect of the crus, and the uniform convolution of the cerebrum.

Cruveilhier describes *a posterior choroid*, a branch of the posterior cerebral, which accompanies the choroid, but turns round the crus cerebri, and, passing upward to supply the corpora quadrigemina, terminates in the velum interpositum and the choroid plexus.

[1] Hare, Tr. Path. Soc. London, ii. 169.

THE CIRCLE OF WILLIS.

The basilar artery, as it divides into the two posterior cerebral arteries, and the internal carotids, as they lie within the brain-case between the carotid canals and the cavernous sinuses, are the most important agents in the formation of a peculiar anastomosis between the vessels of the encranial arterial supply. This anastomosis has received the name of the circle of Willis, and may be thus described:—

The internal carotid artery, and the posterior cerebral artery of one side are united by a small branch of the former—the posterior communicating; so that there are *two* vessels of this name, one on either side of the base of the brain. The anterior cerebral arteries are united by a small vessel called the anterior communicating.

The union of four large streams of blood in this circle must exert a powerful influence over the rhythmical movements of each of its several parts, and thus are explained the alternate elevation and depression so conspicuous in the exposed brain in the living subject.

The capacity of the basilar artery is less than the sum of both vertebrals. Hence it is subject to great strain, and is predisposed to aneurismal enlargements. Hypertrophy of the brain can effect pressure on the circle of Willis only through the basilar artery. This in its turn would cause retardation of the flow of blood along the vertebrals, and an undue strain upon the internal carotids.

The posterior cerebellar artery may be displaced by an aneurism.

THE SUBCLAVIAN ARTERIES.

The Subclavian Arteries are the arbitrarily limited beginnings of the arched vessels that are destined to supply the upper extremities.

Each artery forms an irregular arch, which lies for the most part at the root of the neck. The median abutment of the arch is within the thorax, while the lateral abutment is at the proximal margin of the axilla. The arch is divided into three portions by the position of the Scalenus Anticus muscle. The *first* portion lies to the median border of the Scalenus Anticus. The *second* portion lies behind the Scalenus Anticus. The *third* portion lies beyond the lateral border of the Scalenus Anticus, and extends as far as the lower margin of the first rib.[1]

[1] Authors are not agreed upon the inferior limitation of the third portion of the artery. According to Koch (Langenbeck's Archiv für Klinische Chir., Bd. 10, Heft 1), the vessel extends to the lower border of the Pectoralis Minor. Cruveilhier and some

The *right* subclavian artery arises from the termination of the innominate artery, opposite the right sterno-clavicular junction, at a point commonly answering in position to the interval between the two heads of the Sterno-Cleido-Mastoideus muscle. It curves outward over the superior thoracic aperture and the apex of the lung, between the Scalenus Anticus and Scalenus Medius muscles, to terminate at the lower margin of the first rib.

The *left* subclavian artery arises from the arch of the aorta, passing upward from a much deeper point than the right, but, from the position of the Scalenus Anticus muscle, it pursues a course to the left, similar to that which the right artery pursues to the right.

It follows, from what has been said, that the second and third parts of both subclavian arteries are alike, while the first parts are different, and demand separate descriptions of their relations.

The First Part of the Subclavian Artery:

Relations of the First Part of the Right Subclavian Artery.—In front of this portion lie the sternal end of the clavicle, the upper portion of the sterno-clavicular articulation, the Platysma Myoides, the clavicular attachments of the Sterno-Cleido-Mastoid muscle, with the Stylo-Hyoid and Stylo-Thyroid muscles, the deep cervical fascia, the terminations of the internal jugular and the vertebral veins, and the superior and middle cardiac nerves, as well as the pneumogastric and phrenic. Very rarely the pneumogastric nerve may effect a plexiform arrangement of its filaments about the vessel. Behind lie the recurrent laryngeal nerve and the transverse process of the seventh cervical vertebra. Sometimes the phrenic nerve lies also behind the vessel. To the lateral side is the mediastinal pleura,[1] which separates it from the lung. The vessel is surrounded by cellular tissue, and by a great number of lymphatic glands, together with a few loops formed by the great sympathetic nerve. Sometimes the subclavian vein lies close *beneath* the clavicle.

In the living subject the pulsation of the vessel can be detected a little above the clavicle, and to the outer side of the Sterno-Cleido-Mastoideus muscle. Pressure downward and inward against the pulsating point will compress the vessel against the first rib.

Ligation of the First Part of the Right Subclavian Artery.—An incision beginning just above the upper margin of the sternum is prolonged outward to the distance of three inches. It is met by a second, two inches in length, corresponding to the median margin of the Sterno-Cleido-Mastoid muscle. The latter structure being exposed, it is freely divided in its sternal portion, and partially divided in the clavicular. The anterior jugular vein is now seen, and is carefully held to one side. The Sterno-Hyoid and Sterno-Thyroid muscles are next successively taken up on the grooved directors, and divided. By tearing through the connective tissue over the position of the sheath of the great vessels, the direction of the common carotid artery is ascertained, the sheath opened, the internal jugular vein held to the outer side, and, the artery being used as a guide, the finger is carried along it to the origin of the vessel from the innominate artery. The trunk of the subclavian is felt to the outer side of the carotid, and is carefully exposed. The immediate relations of pneumogastric and cardiac branches of the sympathetic nerves over the artery, the recurrent laryngeal passing behind it, the phrenic nerve passing downward obliquely over the Scalenus Anticus, must be borne in mind in passing the needle round the vessel from below upward. The pleura lies beneath and to the outer side of the artery, and is in direct contact therewith.

The formula of the *collateral circulation*, after ligation of the subclavian artery at its first part, is as follows:—

$$\text{Thyroid axis} \left(\begin{matrix} \text{Transversalis Colli} \\ \text{Supra-scapular} \end{matrix} \right) + \text{Subscapular.}$$

or

$$\text{Thyroid axis} \left(\begin{matrix} \text{Transversalis Colli} \\ \text{Supra-scapular} \end{matrix} \right) + \left\{ \begin{matrix} \text{Subscapular} \\ \text{Intercostal.} \end{matrix} \right.$$

Relations of the First Part of the Left Subclavian Artery.—The first part of the left subclavian is more deeply situated, and is longer, than the corresponding portion of the right. It lies upon the side of the vertebral column, from the third to the first dorsal vertebra. Upon reaching the base of the neck, it arches over the first rib to pass behind the Scalenus Anticus muscle, where it ends in the second portion of the artery.

The relations differ in the thoracic and cervical parts as follows:—

The Thoracic Portion.—The vessel is nearly vertical, with a slight inclination outward. In front are the left innominate vein, a portion of the left lung, and, for a short distance, a part of the œsophagus. Behind lie the Longus Colli muscle, the inferior cervical ganglion of the sympathetic, and the beginning of the thoracic duct. To its outer side, and in direct contact with it, is the pleura. To the inner side and inclining to the front are the pneumogastric and phrenic nerves; to the inner side, still on a plane anterior to the artery, are the trachea and the left carotid artery; to the inner side, and on the same plane as the artery, are the thoracic duct, the left cardiac nerve, and the œsophagus.

The Cervical Portion.—At the base of the neck the artery is crossed obliquely by the phrenic nerve, and at an angle by the subclavian vein. The internal jugular vein lies in front. Behind is the thoracic duct. In the neck the left subclavian artery lies on a somewhat deeper plane than that of the right, and crosses the first rib somewhat further from the sternal end.

clinical writers give the clavicle as the lateral limit of the vessel. The axillary artery in this interpretation would extend upward as far as the clavicle.

[1] Cases of aneurism of the subclavian artery have been reported in which there occurred fatal hemorrhage into the pleural cavity. Pleuritis is one of the dangers attending ligation of the first portion of the vessel.

Remarks.—R. L. MacDonnell[1] describes a dissection of the parts involved by cancer of the supra-clavicular portion of the left lung. The carotid artery was pressed outward, *as was also the first part of the left subclavian artery*, while the third portion was reduced to the size of the radial, and obliterated by a coagulum.

In phthisis a fibrous deposit has been found by R. Quain to surround and obliterate the left subclavian and left vertebral arteries.[2]—Embolus is of more frequent occurrence in the left subclavian artery than in the right.[3]

Ligation of the left subclavian artery to the median side of the Scalenus Anticus is an operation of exceptional difficulty. The details do not appear to require repetition here, since it is not likely that the attempt would be made without careful preparation on the cadaver.

The Second Part of the Subclavian Artery lies in the triangular space between the Scalenus Anticus in front and the Scalenus Medius behind. It represents the highest portion of the curve of the main trunk. Above, and in part behind, lies the brachial plexus. In front lie the Scalenus Anticus, the phrenic nerve, the Sterno-Cleido-Mastoideus, the cervical fascia, the Platysma Myoides, and the integument.

The under surface of the artery lies along the outer aspect of the cervical projection of the pleural sac.

Ligation of the Second Part of the Subclavian Artery.—Since this portion of the artery lies behind the Scalenus Anticus muscle, and is in contact with the pleura, and near the internal jugular vein, its ligation is generally thought to be a more hazardous operation than the ligation of the first part. Moreover, it is nearer the origin of branches of unknown disposition and number, since the thyroid axis, first intercostal, and the deep cervical arteries are variable, and may interfere with the formation of a clot in the artery on the distal side of the ligature. The operation for the ligation of the vessel in its third portion can be readily used as a method of general procedure for that of the second, by careful division of the Scalenus Anticus at its insertion, by strict avoidance of the phrenic nerve normally seen running thereon, and by so disposing of the point of the needle as to avoid injuring the pleura.

The Third Part (outer part or third) of the Subclavian Artery extends from the outer border of the Scalenus Anticus muscle downward and outward to the lower border of the first rib.

The vessel thus lies at first at the base of the neck, and is here in relation with the Omo-Hyoid muscle above, the Scalenus Anticus muscle to the median side, and the upper border of the first rib below. To its lateral side lies the lower border of the brachial plexus. In front, and between it and the integument, lie the deep cervical fascia, Platysma Myoides, superficial fascia, and the skin. Beneath and at a variable distance to its median side lies the pleura.—After reaching the first rib the vessel lies upon the anterior surface of this bone obliquely from above downward and from within outward. In front lie the clavicle and the Subclavius muscle. Crossing it vertically in front is the anterior thoracic nerve. To the outer side is the brachial plexus. The first dorsal nerve rarely passes between the subclavian artery and the subclavian vein. The Scalenus Minimus muscle has been described by Zuckerkandl as passing between the subclavian artery and the brachial plexus.

The subclavian vein lies well to the inner side of the artery, but the vessel may be surrounded by a plexus of veins, or crossed by several large venous trunks, the companion vein of the transversalis colli artery, as well as by the cephalic vein.

On the Vertical Position of the Third Part of the Subclavian Artery in the Neck.—A case of aneurism of the left subclavian artery in a woman aged 30 is recorded by J. M. Warren.[1] The vessel in question was found to pass nearly vertically upward, parallel to, and about an inch from, the lateral border of the Trapezius muscle. The first rib and part of the second were felt passing obliquely across the neck above the clavicle. The insertion of the Scalenus Anticus into the first rib was distinguished. The vessel was the subject of aneurism for the cure of which the recorder successfully ligated the artery in its third part.—In a case recorded by A. Poland[2] the right subclavian artery emerged from between the Scaleni muscles two inches above the clavicle. It then descended nearly vertically to the axilla and passed behind the clavicle a little to the inner side of the junction of the external third, with the internal two-thirds of that bone.—Quain, in his Commentaries on the Arteries, alludes to this arching of the subclavian artery in the neck, and gives the measurements of specimens coming under his notice. Dupuytren (Leçons Orales, t. iv. p. 528) also adverts to the superficial position of the third portion of the artery in those who are thin, and have long, slender necks, with lean and sloping shoulders.—The deviation of the artery is not of unusual occurrence, and may be due either to a congenital or to an acquired condition. In the "Guy's Hospital Reports," 1869, p. 445, are recorded the descriptions of two specimens observed in the dissecting-room. The height to which the vessels rose in the neck was such as to render the direction of the third portion of the artery almost vertical; this occurred in one instance on the right side, and in the other on the left, the artery emerging from behind the Scalenus fully an inch and a half above the clavicle.—

[1] N. Y. Journ. of Medicine, 1850, 155.
[2] Trans. Path. Soc. London, 1850, 51, 85.
[3] Duret, Archiv. Physiol. 1874.

[1] Surgical Observations, 1867, 429.
[2] Med.-Chir. Trans. lii. 177. The remaining remarks in the text on the vertical position of the third part of the subclavian artery are taken from Poland's paper.

The artery lay in the above-named unusual course in a subject used by the Royal College of Surgeons for the examinations for the fellowship. The candidate failed to secure it by the ordinary operation. This failure occurred to a hospital surgeon in a case recorded by M. Dubrueil,[1] where the axillary artery had to be secured in consequence of not finding the subclavian in its usual position.—The acquired displacement of the artery is generally due to the pressure of tumors from below upward, or to an exostosis of the first rib, several cases of which are recorded by Mott,[2] Gregg,[3] and others.

Ligation of the Third Part of the Subclavian Artery.—An incision should extend from the outer fibres of the clavicular portion of the Sterno-Cleido-Mastoideus muscle outward, one-half inch above the upper border of the clavicle and following its curves, to terminate over the clavicular fibres of insertion of the Trapezius muscle. The superficial fascia, Platysma Myoides, and the deep fascia being divided along the entire length of the wound, and the anterior jugular vein drawn to one side, the positions of the Omo-Hyoid muscle and the transversalis colli or supra-scapular artery are made out. The fascia extending from the Omo-Hyoid to the clavicle is divided, and drawn upward out of the way. The shoulder must now be depressed as far as the parts permit, in order to render the wound as shallow as possible, and a search should be made with the finger for the Scalenus Anticus. Using this muscle as a guide, the finger is carried downward until the line of the Scalenus joins that of the first rib. The artery will be found in most instances pulsating in the angle made by these two lines. Should the lower bundles of the brachial plexus be seen at the bottom of the wound, they may aid in securing the vessel, since the latter is known to lie between the plexus and the Anterior Scalene muscle. But the intimacy of this relation also serves to deceive the surgeon, and may, if he be off his guard, lead him to mistake one of the nerves of the plexus for the artery. A nerve trunk has been in this way ligated, or included within the ligature embracing the vessel. To avoid such a mischance the pulsation of any structure whatsoever in the wound should not be relied upon, since the beating of the artery against the lowermost branch of the plexus has been known to lead experienced operators into the error of mistaking the nerve for the artery. On the other hand, the absence of pulsation is not conclusive in determining the nature of any particular texture, since, as a result of exposure, the artery itself may contract and its pulsation cease. The proximity of the pleura to this portion of the artery, while in health an indirect relation, can be converted into a direct relation by aneurismal dilatation of the artery. Prof. Agnew,[4] in speaking of this fact, uses the following language: "Dr. Warren, while isolating this vessel in a case of unusual perplexity, opened the chest, which accident was announced by a distinct whistling sound. The accident in this case did not interfere with the patient's recovery. To avoid such complications the operator should place a finger between the tendon of the Anterior Scalenus muscle and the vessel, and with the point of the director cautiously tear away the existing cellular tissue from the artery, always keeping the instrument directed toward the rib, so that it may not go beyond the proper limitation." The needle should be passed from without inward. The subclavian vein is often not seen during this operation. At other times it swells up into the wound, and requires carefully sustained gentle downward pressure with a retractor to give the operator room enough for his manipulations.

The presence of anomalies, of course, modifies the performance of this operation. The artery may be seen running in front instead of behind the Scalenus. The phrenic nerve may run across the third part of the subclavian artery. Lymphatic glands may be enlarged and numerous. The clavicle may be fixed in an elevated position and demand division.

Ashton Key[1] found, in dissecting a limb twelve years after ligation of the subclavian artery at its outer part, the following to be the plan of the *collateral circulation.*

Subclavian.		*Axillary.*
Suprascapular Posterior Scapular	+	Infrascapular.
Internal Mammary	+	Short and Long Thoracic. Infrascapular.

In addition to these, a set of unnamed vessels passing from the subclavian to the axillary immediately surrounded the site of ligation.

The cervical rib (see p. 114), when two or more inches in length, always supports the subclavian artery, and is therefore a reliable guide to its position.[2]

The branches of the subclavian artery are—
The Vertebral.
The Thyroid Axis.
The Internal Mammary.
The Superior Intercostal and Deep Cervical.

THE VERTEBRAL ARTERY.

The Vertebral Artery is the largest branch of the subclavian. It arises from the upper surface of the first part of this vessel, passing through the foramina of the transverse processes of the cervical vertebræ from the sixth upward, and ascends throughout the entire length of the neck, to escape thence above, where it winds round the atlas, to enter the cranium at the foramen magnum. The artery here passes obliquely forward and joins the vessel of the same name of the opposite side to form the basilar artery.

[1] Gaz. Méd. de Paris, 1837, p. 562.
[2] Mott's edition of Velpeau's Surgery, ii. 38.
[3] Dublin Journal, xxv. 211, 1858.
[4] Principles and Practice of Surgery, 1878, 645.

[1] Guy's Hosp. Rep. 1836, 62.
[2] Ludwig Stille, Virchow's Archiv, Bd xxxvi. 1866, 425, figs.; and A. Poland, Med.-Chir. lii. 255. Literature.

A detailed account of the Manner in which the Vertebral Artery passes from the Neck to the Head.—In consequence of the great width of the atlas, the vessel, after passing through the transverse process of the axis, is directed obliquely upward and outward across the inferior articular process of this bone. It enters the corresponding foramen of the atlas, and appears on the upper surface of the posterior arch, where it lies nearly horizontal in a deep groove, and winds abruptly round the posterior edge of the superior articular process. Thence it enters the cavity of the cranium at the foramen magnum, by piercing the occipito-atloid ligament and dura mater. Within the cranium the vessel passes forward and upward to the inner side of the occipito-atloid articulation, at the side of the medulla oblongata, between the olivary body and the anterior pyramid. It soon passes beneath the medulla to incline toward the median line, where it joins the artery of the opposite side at the spheno-occipital junction to form the basilar.

Relations.—For the better appreciation of the relations of the vertebral artery, it is well to divide its course into four parts.

1st. That part between its origin and its entrance into the vertebræ.

2d. That part within the vertebræ.

3d. That part on the posterior arch of the atlas.

4th. That part within the skull.

1st. The vessel lies to the outer side of the common carotid artery, and a little to the inner side, but not infrequently directly behind the thyroid axis, and on a plane deeper than that of either of these structures. It lies within a triangular space of which the subclavian artery forms the base, the Anterior Scalenus muscle the lateral, and the Longus Colli the median border. The internal jugular vein is in front of the artery, and the inferior cervical ganglion of the sympathetic behind it. This portion of the vertebral artery is without branches.

2d. Within the vertebræ the artery is surrounded by filaments of the sympathetic nerve. The vertebral vein lies in front of the artery. Behind it are the nerves tributary to the cervical plexus on their way to the intervertebral foramina. As the artery passes from one vertebra to another it lies between the Inter-Transverse muscles. At these points the artery gives off the lateral spinal and muscular branches.

3d. Upon the posterior arch of the atlas the artery occupies a triangle, of which the Inferior Oblique muscle forms the base; the Superior Oblique, and the Rectus Posticus Major, the outer and inner sides respectively. Beneath it, on the groove of the atlas, is the first occipital nerve. At the transverse process, the Rectus Capitis Lateralis separates the vessel from the occipital artery.

4th. Within the cranium the vessel lies between the medulla oblongata and the occipito-atloid articulation. It passes before or through the filaments of the hypoglossal nerve, and lies to the inner side of the suboccipital nerve. It terminates at the posterior border of the pons Varolii. This portion of the artery yields the remaining branches.

The branches of the vertebral artery are—

- Cervical
  - (*a*) Lateral Spinal.
  - (*b*) Muscular.
- Encranial
  - (*c*) Posterior Meningeal.
  - (*d*) Posterior Spinal.
  - (*e*) Anterior Spinal.
  - (*f*) Posterior Inferior Cerebellar.

(*a*) The *lateral spinal* branches, from four to six in number, enter the spinal canal through the intervertebral foramina, and are distributed to the posterior surfaces of the bodies of the vertebræ and the periosteum. Branches also supply the membranes of the spinal cord; a few delicate twigs pierce the membranes to supply the nerve matter. The artery anastomoses with the anterior and posterior spinals.

(*b*) The *muscular* branches supply the deep muscles of the neck, and anastomose with the ascending and deep cervical arteries.

(*c*) The *posterior meningeal* branch enters the skull through the foramen magnum, and is distributed to the dura mater of the cerebellar fossa and the falx cerebri.

(*d*) The *posterior spinal* artery arises from the median side of the main trunk, below the anterior spinal artery, and passes down the lateral groove of the spinal cord as far as the second lumbar vertebra, sending branches to the posterior roots of the spinal cord, and a delicate ascending branch to the fourth ventricle. The vessel is smaller than the anterior spinal artery, and more tortuous. It anastomoses with branches of the lateral spinal, anterior spinal, and intercostal arteries.

(*e*) The *anterior spinal* branch originates from the median side of the vertebral, a short distance from its termination in the basilar. It unites with its fellow of the opposite side, in front of the medulla oblongata, directly below the level of the foramen magnum. It thence passes as a single somewhat tortuous vessel along the anterior median fissure throughout the entire length of the spinal cord. The vessel gradually decreases in size as far as the cervical enlargement of the cord, from which point it presents a more variable calibre, and is irregularly tortuous near its termination. The artery receives important accessions from the ascending cervical and pre-vertebral branches of the ascending pharyngeal artery in the neck, from the intercostals in the thorax, and from the ilio-

lumbar and lateral sacral at its lower portion. It is covered by the pia mater, to which, as also to the spinal cord, it sends minute branches.

The vertebral artery sends minute branches to supply the sheaths of the nerves arising from the sides of the medulla oblongata.

(*f*) The *posterior inferior cerebellar* branch passes between filaments of origin of the hypoglossal nerve, thence lies in front of the roots of the pneumogastric and the glosso-pharyngeal nerves, and passes round the medulla behind the middle peduncle of the cerebellum to the inferior surface of the cerebellum. It is the largest of the branches of the vertebral, and sends a branch to the choroid plexus of the fourth ventricle, and another longitudinal branch backward in the groove between the cerebellar hemisphere and the inferior vermiform process, upon which it anastomoses with the vessel of the same name of the opposite side, to supply the inferior surface, and the borders of the hemisphere, and the upper portion of the spinal cord.

Variations.—The anterior spinal artery may be formed by a branch of one vertebral only. The inferior posterior cerebellar artery may arise from the basilar or be absent; or it may pursue an aberrant course, and give off the posterior spinal. The right vertebral may arise from the left subclavian and reach the right side of the cervical vertebræ by passing behind the œsophagus. It may arise from the arch of the aorta between the left subclavian and the left common carotid arteries. The vessel may be tortuous before entering the canal designed for its accommodation. It may enter the canal at any of the openings in the transverse processes. The vessel may thus be found to run in the pre-vertebral region of the neck for a variable distance parallel to the common carotid, for which trunk it might be readily mistaken. It may give origin to the inferior thyroid, the first intercostal, and the deep cervical arteries. At the region where the artery terminates, a branch may be given off which interchanges with the branches of the occipital artery. An island may form about the trunk of the hypoglossal nerve, and another in front of the medulla oblongata. The upper as well as the lower portion of the trunk may be tortuous, a disposition which enables the motions of the head and the cervical portion of the vertebral column to take place without violence to this vessel.

Remarks.—*Ligation* of the first portion of the vessel has been resorted to in deep-seated hemorrhage following wounds of the neck.—The incisions recommended for the ligation of the innominate should here be used. The sheath of the common carotid artery and the internal jugular vein are drawn to the median side, and the transverse process of the sixth cervical vertebra is sought for. The artery will be found lying just beneath this process.—The vertebral artery may be lacerated in fracture of the base of the skull.—Rarely, facial palsy has been found to be associated with aneurism of the vertebral artery as it lies in front of the medulla oblongata, a condition due to pressure upon the trunk of the seventh nerve.

THE BASILAR ARTERY.

The Basilar Artery is formed by the union of the two vertebrals. It passes upward and forward along the upper surface of the basilar process of the occipital bone, where it is protected by the arachnoid membrane. It is received above within the median groove of the pons Varolii, the entire length of which it traverses. The vessel divides at the anterior border of the pons into the two posterior cerebral arteries.

Remarks.—According to Cruveilhier, the sectional area of the basilar artery is not equal to the sum of the sectional areas of the vertebrals. Hence the blood received from these vessels must pass with augmented pressure through the basilar.

The character of the basilar artery as essentially a median vessel, composed of two converging elements, is maintained by such observations as the following: Davy[1] found in a specimen of basilar artery a median septum. According to Quain, the artery has been found perforated by a small foramen, which indicated an attempt at division of the vessel along the middle line. Hyrtl mentions a case in which the complete division of the basilar artery into two vessels was accomplished. These subsequently united to form an island, and the posterior cerebral arteries arose from the resultant trunk in the usual manner.

From its position upon the basilar process, the vessel may be compressed by any force operating from above. Brain-tumors, brain-hypertrophy, or any condition producing unusual encranial pressure, may thus impair its vitality. The vessel is found to be frequently the seat of diseased action.[2] Aneurism of the basilar has been known to compress the eighth nerve, and cause deafness, as well as to occasion symptoms indicative of disturbed function in the ninth and tenth nerves. The origins of the sixth and seventh nerves may also be compressed. In hemorrhage from the rupture of the basilar artery, blood may be found lying over the entire base of the brain, as well as in the pons Varolii, from which it may escape to enter the fourth ventricle. Or it may pass around the medulla oblongata and flow into the spinal cord as far as the cauda equina.—A thrombus

[1] Researches, i. 30; also Edinburgh Medical and Surgical Journal, 1838. This arrangement is similar to the occasional union of the two anterior cerebrals into a single trunk.

[2] In view of the fact that the basilar artery lies against an unyielding bony surface, a comparison can be instituted between it and the femoral artery as it winds round the femur, or with it and the popliteal artery throughout its entire length. Diseased action is of common occurrence in all three vessels.

within the basilar artery will be arrested at the point of origin of the posterior cerebral arteries, since these vessels are small and pass nearly transversely outward.

See in addition the account of the circle of Willis.

The branches of the basilar artery are—

(*a*) Transverse.
(*b*) Auditory.
(*c*) Anterior Inferior Cerebellar.
(*d*) Superior Cerebellar.
(*e*) Posterior Cerebral.
(*f*) Branches to the Pons Varolii.

(*a*) The *transverse* branches, from three to four in number on either side, supply the inferior surface of the pons Varolii.

(*b*) The *auditory* branch arises from the basilar near its origin. It passes forward and outward, and enters the internal auditory meatus to supply the labyrinth.

(*c*) The *anterior inferior cerebellar* branch arises from about the middle of the basilar artery, between the sixth and seventh nerves. It passes outward along the middle peduncle of the cerebellum to be distributed to the under anterior surface of the hemisphere of its own side. This appears to be the middle cerebellar artery of some writers. The last-named vessel may be an enlarged transverse artery lying between the inferior and anterior inferior cerebellar arteries.

Remarks.—Aneurism of the anterior inferior cerebellar artery is apt to press on the third, seventh, and eighth nerves. Anosmia may be found to coexist with these symptoms.—Abnormal arrangements of the inferior cerebellar arteries have definite relations to the localization of emboli. The artery may arise from the trunk of the basilar, or from a trunk in common with one of the transverse arteries. The blood supply to this surface, instead of being derived from the vertebral, may come entirely from the basilar. The branches of the transverse vessels may come from the superior cerebellar instead of from the basilar, so that obstruction of the latter artery need not necessarily affect the nutrition of the basal portion of the hemispheres.

(*d*) The *superior cerebellar* branch arises at a right angle from the basilar artery, near its point of division, just behind the anterior border of the pons. Many authors regard it as a terminal branch of the basilar. The superior cerebellar passes outward, lying in the groove which separates the crus cerebri from the pons, winds around the crus parallel to the fourth nerve and the posterior cerebral artery, from which it is separated by the origin of the third nerve. It divides near the corpora quadrigemina into numerous branches, some of which pass inward to supply the superior vermiform process and the valve of the fourth ventricle, while others pass outward to the superior surface of the cerebellum.

A case of aneurism of this vessel has been noted by Bristowe.[1]

(*e*) The *posterior cerebral* branch is one of the two terminal branches of the basilar artery. It passes outward from its origin, winds round the crus cerebri of its own side in front of the third nerve, and, following the course of the great transverse fissure between the occipital lobe of the cerebrum and the cerebellum, supplies by its terminal branches the cortex of the occipital and spheno-temporal lobes of its own side, and the parts lying within and bordering upon the third ventricle.

The branches of the posterior cerebral artery are—

(1) Branches to the Cortical Portion of the Cerebrum.
(2) Branches to the Optic Thalamus.
(3) Branches to the Crus Cerebri.
(4) Posterior Choroid.
(5) Anastomotic.

(1) The *branches to the cortical portion of the cerebrum* supply the occipital lobe, including the calcarine fissure, the region of the hippocampus major, and the spheno-temporal lobe. A branch to the median surface of the occipital lobe at the lingual lobule has received the specific name of the occipital branch.

(2) The *branches to the optic thalamus* pierce the posterior perforated space. Two sets of minute branches are embraced under this head, one passing to the median portion of the thalamus (internal posterior arteries), and another passing to the lateral portion (external posterior arteries).

(3) The *branches to the crus cerebri* include a number of minute twigs which enter the crus at its lateral surface.

(4) The *posterior choroid* branch passes forward from the transverse fissure to supply the choroid plexus, the velum interpositum, the pineal gland, the corpora quadrigemina, and the geniculate bodies. The two structures last named may, however, receive their blood supply by distinct twigs from the cortical branches.

(5) The *anastomotic* branches include (1) the *posterior communicating artery*, which joins the posterior cerebral with the internal carotid (see account of the circle of Willis), and (2) the junction between the terminal branches of the posterior cerebral and those of the middle cerebral and the cerebellar arteries.

[1] Trans. Path. Soc. London, x. p. 4.

(*f*) The *branches of the basilar to the pons Varolii* are minute vertical twigs, which are distributed to the entire substance of the pons. They bear a close resemblance to the branches of the anterior spinal artery.

The middle cerebellar artery. Under this name Duret describes a branch of the basilar artery passing to the basal surface of the cerebellar hemisphere. It sends a few twigs to supply the seventh and eighth nerves at their apparent origins. A small transverse twig supplies the apparent origin of the sixth, and another larger arteriole passes to the apparent origin of the fifth nerve.

Remarks.—Aneurism of the posterior cerebral artery as it curves round the crus will exert pressure upon the spheno-temporal lobe, the corresponding crus, and the pons, as well as upon the second, third, fifth, and seventh nerves. Hemorrhage from the rupture of such an aneurism may raise the floor of the lateral ventricle, and involve the floor of the fourth ventricle (Durand).

Hemorrhage from the branch to the median aspect of the optic thalamus (internal posterior) may create an isolated clot which is either confined to the thalamus or projects into the third ventricle.

Hemorrhage from the branch at the lateral aspect of the optic thalamus (external posterior) will cause laceration of the optic thalamus posteriorly, and the clot may be found extending thence within the crus cerebri as far as the pons Varolii. When the hemorrhage is extensive, the walls of the cavity in the optic thalamus limiting it may rupture, and the blood escape into the third ventricle. Hemorrhage from the branch lying within the calcarine fissure creates a gross lesion in the occipital lobe, which sometimes perforates the calcar avis (hippocampus minor), when the blood-clot will be found lying within the lesser cornu of the lateral ventricle.

THE THYROID AXIS

arises from the anterior surface of the subclavian artery in the first part of its course, at a point opposite the vertebral artery, and to the median side of the Scalenus Anticus muscle. After ascending a few lines, it terminates by division as follows:—

Inferior Thyroid.
Suprascapular.
Transversalis Colli.

THE INFERIOR THYROID.

The Inferior Thyroid artery appears to be the continuation of the stem of the thyroid axis. It passes upward on the Longus Colli muscle as far as the fifth cervical vertebra, at which point it inclines inward to reach the thyroid body, where it freely anastomoses with the artery of the opposite side and the superior thyroid artery. The vessels enter the base of the body at the sides and beneath.

In bronchocele, the vessels supplying the thyroid body are greatly increased in volume. No matter to what size the growth may attain the vessels always preserve the usual relation to the under surface and basal borders of the thyroid body. This fact is of importance in extirpating tumors of this organ. W. W. Greene,[1] of Portland, Maine, advises that the base of the mass be reached as rapidly as possible in order to compress the source of arterial bleeding.

Relations.—The inferior thyroid of the left side lies upon the œsophagus and near the thoracic duct. These relations are of importance in œsophagotomy. As the artery ascends the neck it lies in front of the inferior laryngeal nerve.

Variations. — The thyroid axis is sometimes absent, when the inferior thyroid secures origin from the subclavian. It may arise in common with the suprascapular, or from the aortic arch between the innominate and the left carotid artery. Jas. Blake[2] has described an inferior thyroid artery of the size of a goosequill, which arose from the innominate artery, crossed the trachea three-fourths of an inch above the sternum, and returned to enter the thyroid body at its right side. It has occasionally been seen to arise from the common carotid. Very rarely, the artery, when of carotid origin, after supplying the side of the thyroid body nearest to it, sends another branch between the trachea and the œsophagus to the opposite side of the thyroid body.

The branches of the inferior thyroid artery are—

(*a*) Ascending cervical.
(*b*) Laryngeal.
(*c*) Tracheal.

(*a*) The *ascending cervical* branch passes upward along the inner side of the phrenic nerve between the Scalenus Anticus and the Rectus Capitis Anticus Major, which it supplies with blood. Branches enter the intervertebral foramina, and are distributed to the spinal cord and membranes. It anastomoses with the ascending pharyngeal.

(*b*) The *laryngeal* branch arises near the branches entering the thyroid body. It ascends behind the inferior angle of the thyroid cartilage, and supplies the muscles and the mucous membrane of the larynx.

(*c*) The *tracheal* is one of the most constant of the branches of the inferior thyroid. It arises opposite the transverse process of the seventh cervical vertebra, and descends behind the trachea as far as the bifurcation, giving branches to the œsophagus, trachea,

[1] Amer. Journ. Med. Sci., Jan. 1871, 80.
[2] St. Louis Med. and Surg. Journ., June, 1848.

bronchial lymphatic glands, and to the thoracic portion of the Longus Colli muscle. It anastomoses with the superior intercostal and bronchial arteries.

THE SUPRASCAPULAR.

The Suprascapular artery (transverse scapular, transverse humeral) passes downward and outward behind the clavicle and the Sterno-Cleido-Mastoideus and Trapezius muscles, and upon the Scalenus Anticus. It reaches the neck of the scapula, and, winding around it, enters the infraspinous fossa, to anastomose with the subscapular artery.

Its branches are—

(*a*) Thoracic.
(*b*) Acromial.
(*c*) Supraspinatus.
(*d*) Infraspinatus.

(*a*) The *thoracic* branch supplies the Subclavian muscle.

(*b*) The *acromial* branch supplies the acromial attachment of the Trapezius muscle and the skin over the acromion.

(*c*) The *supraspinatus* branch supplies the muscle of the same name. Many writers regard this branch as the termination of the axis of the main trunk.

(*d*) The *infraspinatus*, in addition to supplying the Infraspinatus muscle, sends a small branch along the axillary margin of the scapula, which anastomoses with the posterior scapular branch of the transversalis colli.

Variations.—The suprascapular may arise from the subclavian artery either singly or in common with the transversalis cervicis. More rarely it arises in conjunction with the internal mammary artery. It may even arise from the axillary or the subscapular artery.

THE TRANSVERSALIS COLLI.

The Transversalis Colli artery is larger and more tortuous than the preceding. It passes directly outward beneath the Sterno-Cleido-Mastoideus and Trapezius muscles, and in front of the Scaleni and the phrenic nerve. In the neighborhood of the superior angle of the scapula, it divides beneath the Levator Anguli Scapulæ into two branches:—

(*a*) Superficial Cervical (Ascending).
(*b*) Posterior Scapular (Descending).

(*a*) The *superficial cervical* branch passes upward in the posterior cervical region, and supplies the Trapezius, Levator Anguli Scapulæ and Splenius muscles, and anastomoses with the descending branch of the occipital artery.

(*b*) The *posterior scapular* branch passes downward along the whole of the vertebral border of the scapula. It supplies the Rhomboideus, Serratus Magnus, and Latissimus Dorsi muscles, as well as in part the Levator Anguli Scapulæ. It anastomoses with the infraspinatus branch of the suprascapular artery. A small branch extending parallel with the main trunk aids the subscapular artery in supplying the Subscapularis muscle.

Variations.—The transversalis colli artery may be absent, and its place taken by a deep cervical artery, having an ascending and a descending branch, and arising from the outer third of the subclavian artery. It may arise from the subclavian artery, and, except in passing through the brachial plexus, be found to answer to the above description.

THE INTERNAL MAMMARY ARTERY

arises opposite the inferior thyroid artery. It passes downward and slightly forward and inward, along with and parallel to the Scalenus Anticus muscle, to a point behind the sternal end of the clavicle, and there enters the thorax. Passing downward beneath the pleura, along the posterior surface and near the border of the sternum, the artery reaches the lower part of the body of this bone, at which point it lies beneath the Triangularis Sterni, and at the level of the sixth or seventh rib divides into its terminal branches.

Relations.—In front is the descending vena cava, and, in the first part of its course, the Sterno-Cleido-Mastoideus muscle. The phrenic nerve lies at first to its outer side, but afterward runs parallel to it.

The branches of the internal mammary are—

(*a*) Superior Phrenic.
(*b*) Thymic.
(*c*) Anterior Intercostal.
(*d*) Anterior (Perforating).
(*e*) Musculo-Phrenic.
(*f*) Abdominal.

(*a*) The *superior phrenic* artery passes between the pericardium and pleura to reach the Diaphragm. It anastomoses with the musculo-phrenic branch and the inferior phrenic artery from the aorta.

(*b*) The *thymic* branches supply the thymus body, the lymphatic glands, and the fatty and connective tissue in the same locality. Pericardial branches may be given off near the thymic.

(*c*) The *anterior intercostal* arteries answer to the intercostal spaces. They arise from the sides of the main artery, at the intercostal spaces, from the first to the sixth or seventh, two branches being given to each interval. One of these runs along the lower border, the other along the upper border of the space. At first

lying between the pleura and the Internal Intercostal muscle, they run for the greater part of their course between the Internal and External Intercostals.

(*d*) The *anterior* (*perforating*) branches pierce the sternal portion of the intercostal spaces to supply the Pectoral muscles and the mammæ, in which they are assisted by branches from the anterior intercostal. They are greatly enlarged during lactation.

(*e*) The *musculo-phrenic* is the outer main division of the artery. It supplies the Diaphragm, the lower Intercostal muscles, where they form twigs known as the *anterior intercostals*, and the upper portion of the anterior abdominal wall.

(*f*) The *abdominal* (*superior epigastric*) branch passes downward behind the Rectus Abdominis. It supplies this in common with the other abdominal muscles, and anastomoses with the deep epigastric artery. It sends twigs to the Diaphragm and to the integument.

Variations.—The internal mammary may arise from the thyroid axis or the scapular arteries, and rarely from the innominate artery or the aorta. Occasionally it is double on each side.

THE SUPERIOR INTERCOSTAL AND DEEP CERVICAL ARTERIES.

It is convenient to treat of these arteries under one head, since they commonly arise from the subclavian by a single trunk. This vessel arises behind the Anterior Scalene muscle on the right side, and immediately at the inner side of the corresponding muscle on the left side. It passes backward and slightly downward over the thoracic wall, and divides into two branches, as follows:—

(*a*) Superior Intercostal (descending trunk).

(*b*) Deep Cervical (ascending trunk).

(*a*) The Superior Intercostal passes over the pleura at the apex of the lung, and enters the thorax in front of the neck of the first rib, to the outer side of the first thoracic ganglion of the sympathetic. The artery supplies the muscles of the first and in part those of the second intercostal space. It sends minute branches to the dorsal region, and a small twig to the spinal cord, through the neighboring intervertebral foramen.

(*b*) The Deep Cervical artery (posterior cervical) ascends vertically, reaching the posterior cervical region between the transverse process of the last cervical vertebra and the first rib. It thence ascends vertically between the transverse and spinous processes of the cervical vertebræ, and lies beneath the Complexus muscle. It supplies the deep muscles of the neck, and anastomoses with branches of the vertebral and the descending branch of the occipital artery.

General Remarks on the Branches of the Subclavian Artery.—The arrangement of the branches of the subclavian artery, above presented, is for the most part the one generally accepted by anatomists both in this country and in England. It is nevertheless but justice to Mr. Quain to say that, in his work on the anatomy of the arteries (the most authoritative in the English language), he declares that the branches as frequently present irregular disposition as they do the arrangement called average in anatomical text-books. It need not excite comment, therefore, if departures from the descriptions above accepted are occasionally noted. Thus Henle describes the thyroid axis, under the name of the thyro-cervical trunk, as having four branches, the *inferior thyroid;* the *ascending cervical*, which supplies the deep muscles of the neck, ascending as far as the atlas, where it anastomoses with the ascending pharyngeal; the *superficial cervical* (transversalis colli); and the *transverse scapular* (suprascapular). The third portion of the vessel gives off independently the *transversalis colli* (posterior scapular).

J. B. Pervin[1] found in eleven subjects out of fifty the *transversalis colli* arising as described by Henle, and in fourteen to arise independently of the axis, from the second part of the subclavian artery. In another series of examinations he found the artery arising in nearly half the number of examples from the third part. It becomes, therefore, an important fact for the surgeon to remember, in ligating the subclavian artery in its third part, that in a large percentage of cases an artery may be found, contrary to the statements of many observers, springing directly from it.

No explanation of the frequent variations in these branches has yet been given. Students of the subject have neglected stating any related facts, such as the anatomy of the muscles and of the nerve trunks in the vicinity, or the departures which such branches exhibit from the arrangement of the corresponding vessels in the lower animals.

Since the frequent use of the word "cervical" in the names of branches of the subclavian artery has led to some confusion, the following grouping of the three main "cervical" branches may prove of service. The *superficial cervical* branch supplies the upper portion of the Trapezius, the Levator Anguli Scapulæ, the Rhomboideus, and the Serratus Posticus Superior. These muscles, with the exception of the last-named, are associated in nature (see Variations of these muscles, pp. 274–276), and might receive the name of the Cephalo-humeral group.—The *deep cervical* branch

[1] Brit. and For. Med.-Chir. Rev., lvii. 1876, 186.

supplies the Complexus and other deep muscles of the vertebral series, and thus has no organic connection with the muscles inserted into the superior extremity. —The *ascending cervical* artery supplies the Scalene muscles, which may be said to constitute the superior Costo-Vertebral group of muscles.

THE AXILLARY ARTERY.

The Axillary Artery is the continuation of the subclavian. It begins at the lower (lateral) border of the first rib, and ends at the lower border of the tendons of the Latissimus Dorsi and Teres Minor muscles behind, and the lower border of the Pectoralis Major in front.

It proceeds obliquely downward and backward across the arm-pit, changing its position slightly according to the position of the limb. When the superior extremity is at rest, the vessel describes a curve downward and inward, the convexity being directed toward the shoulder. The artery is situated more deeply above than below, where it is covered by the skin and fascia only. Below, it lies near the humerus, from which it is separated by the Coraco-Brachialis muscle.

The axillary artery is divided for convenience into three portions. The first portion includes that part of the vessel lying above the tendon of the Pectoralis Minor muscle; the second portion lies behind the tendon; and the third lies below it.

Relations.—*The first portion of the axillary artery.* In front it is covered by the skin, the Platysma Myoides, the cephalic vein, and the costo-coracoid membrane. Beneath, it rests against the external layer of the first Intercostal muscle and the Serratus Magnus, as well as against a prolongation of the deep cervical fascia, which forms, with the costo-coracoid membrane, a sheath inclosing the artery and vein. To the median side lies the axillary vein, and to the lateral side is the brachial plexus of nerves, the trunk formed by the union of the eighth cervical and first dorsal nerves lying near and a little superficial to the artery.

The second portion lies beneath the Pectoralis Minor, and is embraced by the trunks of the brachial plexus. A quantity of connective tissue lies between the vessel and the Subscapularis muscle; to the lateral side is the insertion of the tendon of the Subscapularis; and to the median side, the axillary vein.

The third portion.—In front of the artery in this portion are the skin, fascia, and the median nerve which crosses the vessel obliquely from within outward. Beneath lie the lower part of the tendon of the Subscapularis, the tendon of the Latissimus Dorsi, and the Teres Minor muscle, as well as the circumflex and musculo-spiral nerves. To the lateral side lie the Coraco-Brachialis muscle, the external cutaneous nerve, and the outer root of the median nerve. To the median side lie the axillary vein, the ulnar, the internal cutaneous and the lesser cutaneous nerves, together with the inner root of the median nerve.

When the arm is forcibly abducted, the axillary artery at its third portion rests on the Subscapularis muscle.

Ligation of the Axillary Artery.—For the operation of ligation of the artery near its origin, an incision three inches long is made, beginning one inch from the sternal end of the clavicle, and extending to the anterior edge of the Deltoid muscle. The Pectoralis Major is drawn downward, and the costo-coracoid membrane carefully divided upon a grooved director. The operator should then search for the acromial branch of the artery, which ordinarily lies in the loose connective tissue beneath the membrane. Using the acromio-thoracic artery as a guide, the artery is seen lying deep in the wound between the vein and the brachial plexus of nerves. If seen, the vein should be drawn to the median side, and the needle passed from within outward. This operation is rarely performed, the ligation of the outer third of the subclavian being easier and safer. For obvious reasons the ligation of the axillary at its second portion is rarely attempted. For ligation of the axillary artery at its lower portion, the elbow is flexed, the arm is abducted, and an incision three inches long made in the axillary space, a little nearer the median than the lateral side. Using the inner border of the Coraco-Brachialis muscle as a guide, a careful search for the artery is instituted in the loose connective tissue. The axillary vein is first exposed, and, on drawing this to the median side, the artery is disclosed lying to the median side of the median nerve. The needle is passed from within outward.

The *collateral circulation* varies according as the artery is ligated above or below the subscapular.

Above Subscapular	Subscapular	other arteries about the scapula.
	Long Thoracic	Internal Mammary and Deep Epigastric.
Below Subscapular	Posterior Circumflex	Suprascapular and Acromial-Thoracic.
	Subscapular	Superior Profunda.

Mr. Skey reports[1] an instance in which this artery was wounded by spicules of bone from a fractured humerus. A diffused aneurism ensued, ending in death.

The branches of the axillary artery are—

(*a*) Superior Thoracic.
(*b*) Acromial-Thoracic.
(*c*) Long Thoracic.
(*d*) Thoracica Alaris.
(*e*) Subscapular.
(*f*) Posterior Circumflex.
(*g*) Anterior Circumflex.

(*a*) The *superior thoracic* arises from the first part of the vessel, as high up as the Subclavius muscle. It is often a branch of the acromial thoracic. Crossing

[1] Lancet, 1859, ii. 661.

the first intercostal space, where it gives branches to the upper portion of the thoracic wall, it passes to the Pectoral muscles, between which it gives off branches to supply more particularly the Pectoralis Minor. It also supplies the skin and the mammary gland, and anastomoses with the intercostal and internal mammary arteries.

(*b*) The *acromial thoracic* artery is larger than the preceding, and arises from the first portion of the axillary between the Pectoralis Minor and the costo-coracoid membrane. It at once divides into two branches, a descending and an acromial branch. The *descending* is lodged within the groove between the Deltoid muscle and the Pectoralis Major, where it is in company with the cephalic vein, and anastomoses with the anterior circumflex artery. Most of its branches pass to the Deltoid muscle.

The *acromial*, the larger of the two branches, passes outward along the lower border of the clavicle, crossing the coracoid process and the coraco-acromial membrane to reach the acromion process, in the neighborhood of which its terminal branches are distributed to the Deltoid and Supra-Spinatus muscles and to the articular tissues in the region of the shoulder. It anastomoses with the transverse scapular artery. In addition to the above the artery sends branches to the Serratus Magnus and Subclavius muscles. In some subjects branches pass to the Pectoralis Major on its deep surface, and perforate the sternal margin of the muscle to supply the skin.

(*c*) The *long thoracic* artery arises from the first division of the axillary, directly below, though sometimes behind, the Pectoralis Minor. It passes obliquely inward down the side of the chest between the Pectoralis Major and the anterior border of the Serratus Magnus muscle as far as the sixth intercostal space. It supplies the Pectoralis Major, the Serratus Magnus, the corresponding Intercostal muscle, the mammary gland, and the skin. The posterior branches anastomose with the intercostal and subscapular arteries.

(*d*) The *thoracica alaris* is a small inconstant vessel distributed to the lymphatic glands and fat of the axilla. It is often a branch of the acromial thoracic.

(*e*) The *subscapular artery* answers in position nearly to the inferior border of the Subscapularis muscle. It is the largest of the branches of the axillary. It arises from the third portion of that vessel close to the lower edge of the Subscapularis muscle. Having the musculo-spiral nerve on the median side, it descends toward the axillary border of the scapula, where it divides into two branches, a descending and a dorsal or scapular branch. The *descending branch* is a continuation of the artery which passes along the axillary border of the scapula, in company with the subscapular nerve, between the Serratus Magnus and the Latissimus Dorsi, and is distributed chiefly to these muscles, and to the Subscapularis and the Teres Major, at the same time sending branches to the skin. It anastomoses with the terminal portion of the dorsal branch. The *dorsal* or *scapular branch*, as a rule larger than the preceding, arises from the main vessel at the upper portion of the axillary border of the space between the Teres muscles, where it forms a slight groove in the bone a short distance below the long head of the Triceps. As it lies beneath the Teres Minor, on its way to the dorsum of the scapula, it divides into branches for the Infra-Spinatus and Teres Minor muscles. It anastomoses with the posterior and superior scapular arteries.

(*f*) The *posterior circumflex* arises from the posterior surface of the trunk, opposite the lower border of the Subscapularis, and close to the preceding artery. It passes through the quadrangular space defined by the humerus within, the long head of the Triceps without, the Subscapularis and Teres Minor muscles above, and the Teres Major and Latissimus Dorsi below. It winds around the posterior aspect of the surgical neck of the humerus to reach the under surface of the Deltoid muscle, to which it sends numerous branches. Several small branches are given off to the shoulder-joint, the Latissimus Dorsi, and the Triceps before the artery reaches its destination. It anastomoses with the descending branch of the acromial-thoracic and subscapular arteries.

(*g*) The *anterior circumflex*, much smaller than the posterior, arises at about the same level with it on the anterior surface of the trunk. It passes outward and forward, and winds around the anterior surface of the region of the surgical neck of the humerus, beneath the Coraco-Brachialis muscle, and the short head of the Biceps, to reach the bicipital groove where it often terminates. It may cross this groove to reach the median border of the Deltoid, within which it is distributed to anastomose with the posterior circumflex artery. It sends a short descending branch to the periosteum of the bicipital groove, and a longer one which may ascend as high as the capsular ligament and the synovial membranes, to which, in this event, it sends branches, while the remainder of the artery, anastomosing with a branch of the acromial-thoracic, is lost in the head of the humerus. The artery supplies in addition the Subscapularis and those muscles arising from the coracoid process.

Remarks.—A curious accident to these vessels, in connection with the discharge of cannon, has been described.[1] The discharge was received by the hand, which was in part lacerated and destroyed, while the whole extremity, as far as the axilla, was carried backward by the explosion with a degree of violence sufficient to rupture the axillary vessels. In such cases the acromial ligaments may be ruptured, while the shoulder-joint, the ribs, and the clavicle escape.

Variations.—The variations of the axillary artery and its branches are included under two heads: (*a*) those parts embraced in the trunk, and (*b*) those included in the exserted portion of the limb.

(*a*) The trunkal branches are best studied in connection with the nature of the muscular attachments of the shoulder. The fact that the branches of the subclavian, supplying the Trapezius, the Levator Anguli Scapulæ, the Rhomboidei, and the Scaleni muscles, may in rare cases arise from the axillary artery is easily understood when the variations of these muscles (see p. 276) are borne in mind. The variations, consisting of interchanges of the superior thoracic, the acromial thoracic, and the long thoracic, are in like manner understood if the pectoral significance of these branches be remembered. The superior thoracic and the acromial thoracic often arise from a common trunk which has received the name of the thoracic axis.—The subscapular is apt to dominate the other branches and some of the branches of the brachial. Thus the posterior circumflex and the superior profunda are seen arising from the subscapular; an arrangement suggesting the plan normally pursued in the thigh, where the profunda femoris represents the subscapular. Or the posterior circumflex may dominate, when the anterior circumflex, the superior profunda, and the dorsal scapular artery will arise from it.—The dorsalis scapulæ may arise from the axillary artery.

(*b*) Some of the most interesting variations of the axillary are comprised in what may be called the distal variations, *i. e.*, those embraced in the arrangement of branches of the artery to the arm, the forearm, and the hand. In the preceding section the superior profunda is seen arising from the axillary, an arrangement which may be said to connect one group with the other. Rarely a complementary ulnar artery arises from the axillary or one of its branches, and has received the name of the *collateral ulnar*.—The artery may divide into the radial and the ulnar, or both of these vessels be present together with the interosseous artery.

The branches of the brachial plexus of nerves may embrace a branch of the artery instead of the main stem. In such an instance it may be assumed, according to Quain, that the main stem of the brachial artery has been obliterated, "and that there has been developed in its place, as an apparent brachial artery for the supply of the lower portions of the limb, a vas aberrans, such as is sometimes seen arising from the brachial artery, and uniting with one of its branches."

[1] Br. Med. Journ., Sept. 23, 1871, 342.

THE BRACHIAL ARTERY.

The Brachial Artery is the continuation of the axillary. It begins at the lower margin of the Latissimus Dorsi muscle, and passes downward and somewhat obliquely outward, pursuing a straight course to terminate at the side of the coronoid process of the ulna, where it divides into the radial and ulnar arteries. It lies in the groove between the flexor and extensor muscles of the arm.

Relations.—In front are the brachial fascia and the skin; to the outer side are the Coraco-Brachialis and the median margin of the humerus; to the median side are the fascia and the skin, from which the artery is separated by the tendon of the Coraco-Brachialis. Behind, the artery lies on the Triceps above, and the Brachialis Anticus below. The vessel is superficial till it reaches the elbow, when it sinks within a triangular area, bounded on the median side by the Pronator Radii Teres, on the lateral by the Supinator Longus, behind by the Brachialis Anticus, and in front by the semilunar fascia from the tendon of the Biceps. Within this space, and to the inner side of the Supinator Longus, is the tendon of the Biceps, to the inner side of which in turn is the brachial artery.

The relations of the artery being complicated, the usual method of description will be departed from, and the relations of the veins and nerves to the vessel separately given. The *veins* (venæ comites) are generally two in number, one on either side of the vessel. Of these the larger is on the inner side. Here and there they are united by transverse veins either in front or behind the artery. The venæ comites unite with the basilic veins by perforating the brachial fascia about the middle of the arm. Of the superficial veins at the elbow, the median basilic passes over the aponeurotic slip from the tendon of the Biceps.—The *nerves* are branches of the brachial plexus, and are arranged as follows:—

The median nerve is inclosed in the same sheath with the artery and the veins. Above, it lies to the outer side, then upon the vessel, and finally, at the middle or lower third, crosses it, and near the elbow appears to the inner side. Above, the external and internal cutaneous nerves are also inclosed in the sheath.—The ulnar nerve lies to the inner side, inclosed in a separate sheath. At first it lies near the vessel, but, toward the elbow, passes far to the inner side of the arm.—The musculo-spiral nerve lies behind the artery at its origin, but soon winds around on the posterior surface of the humerus.—The external cutaneous nerve lies to the outer side of the artery, separating it from the Coraco-Brachialis muscle; toward the middle of the arm, however, it pierces the last-named muscle, and enters into new relations.—The internal cutaneous lies to the inner side, and separates the median from the ulnar nerve. The Biceps, when well developed, may project a little over the vessel.

The position of the vessel is indicated by a line drawn from a point midway between the folds of the axilla to a point midway between the epicondyle and the epitrochlea of the humerus.

Variations.—The brachial artery may be shorter than usual, owing to the radial and ulnar arteries arising above the elbow, when the artery is said to undergo the "high division." In rare instances the vessel may be absent, when the axillary artery is said to terminate by division into the radial and ulnar arteries. In some forms of "high division," the interosseous artery may represent the main stem of the brachial artery, *i. e.*, it may extend down the arm to the interosseous space, at the same time that the radial and the ulnar arteries occupy respectively the median and lateral borders of the arm. The artery may be of normal length, but may lie upon the deep fascia.

The proximity of the elbow-joint and the presence of the slip from the tendon of the Biceps muscle to the fascia of the forearm frequently serve to determine the site of variations.—The artery, as it lies just above the elbow, may thus, in aged persons, be curved or contorted. In subjects of all ages, the artery at this point may be forced from the straight line by the material employed to fill the bloodvessels.—The artery and the median nerve pass through the rarely-present epitrochlear foramen or under the epitrochlear process (see p. 175).—The artery may divide either proximally to or beneath the slip of the Biceps tendon.—It may divide at a point a little distally to the centre of the joint. Rarely an island-formation occurs in the trunk.[1]

The artery may be overlaid by an accessory head of the Biceps, by the Pronator Radii Teres muscle, by the Brachialis Anticus, or by the tendon of the Coraco-Brachialis. It may lie beneath the nerve, or between it and the Brachialis Anticus.

The branches of the brachial artery are as follows:—

(*a*) Superior Profunda (profunda brachialis).
(*b*) Inferior Profunda (collateralis ulnaris superior).
(*c*) Nutrient Artery of the shaft.
(*d*) Anastomotica (collateralis ulnaris inferior).
(*e*) Muscular branches.

(*a*) The *superior profunda* arises from the posterior part of the vessel below the lower margin of the Teres Major muscle. It enters the groove between the inner and outer heads of the Triceps muscle, in company with the musculo-spiral nerve, to gain the outer side of the arm, where, near the insertion of the Deltoid muscle, it divides into two branches, the anterior and the posterior.—The *anterior* branch pierces the external intermuscular septum, and lies between the Brachialis Anticus and Supinator Longus muscles. It gives branches to the Deltoid, Triceps, and Brachialis Anticus, and to the muscles arising from the outer condyloid ridge of the humerus. It anastomoses with the anterior radial recurrent.—The *posterior* (articular) branch descends vertically to supply the third head of the Triceps, and, reaching the elbow-joint, anastomoses with branches of the recurrent interosseous.

The anterior branch will sometimes descend vertically along the outer side of the arm to a position behind the epicondyle.

(*b*) The *inferior profunda*, smaller than the preceding, arises opposite the insertion of the Coraco-Brachialis muscle, a little below the middle of the forearm. It passes downward and backward, piercing the intermuscular septum, to reach the Triceps muscle, on the anterior face of which it descends to the epitrochlea.

(*c*) The *nutrient artery* of the shaft enters the humerus through a foramen upon the median side of the middle portion of the shaft. It is directed downward, and supplies the interior of the bone. It may perforate the Coraco-Brachialis.

Harrison[1] describes a case of aneurism of this vessel, the result of fracture of the humerus, for which amputation of the arm became necessary.

(*d*) The *anastomotica artery* arises from the main trunk, about two inches above the bend of the elbow. It supplies the Brachialis Anticus, the third head of the Triceps, and the origins of the flexor muscles of the forearm, besides sending a branch across the posterior surface of the humerus above the olecranon fossa. The artery anastomoses with both ulnar recurrent arteries.

(*e*) The *muscular branches* supply chiefly the muscles on the front part of the arm, viz., the Biceps and the Brachialis Anticus.

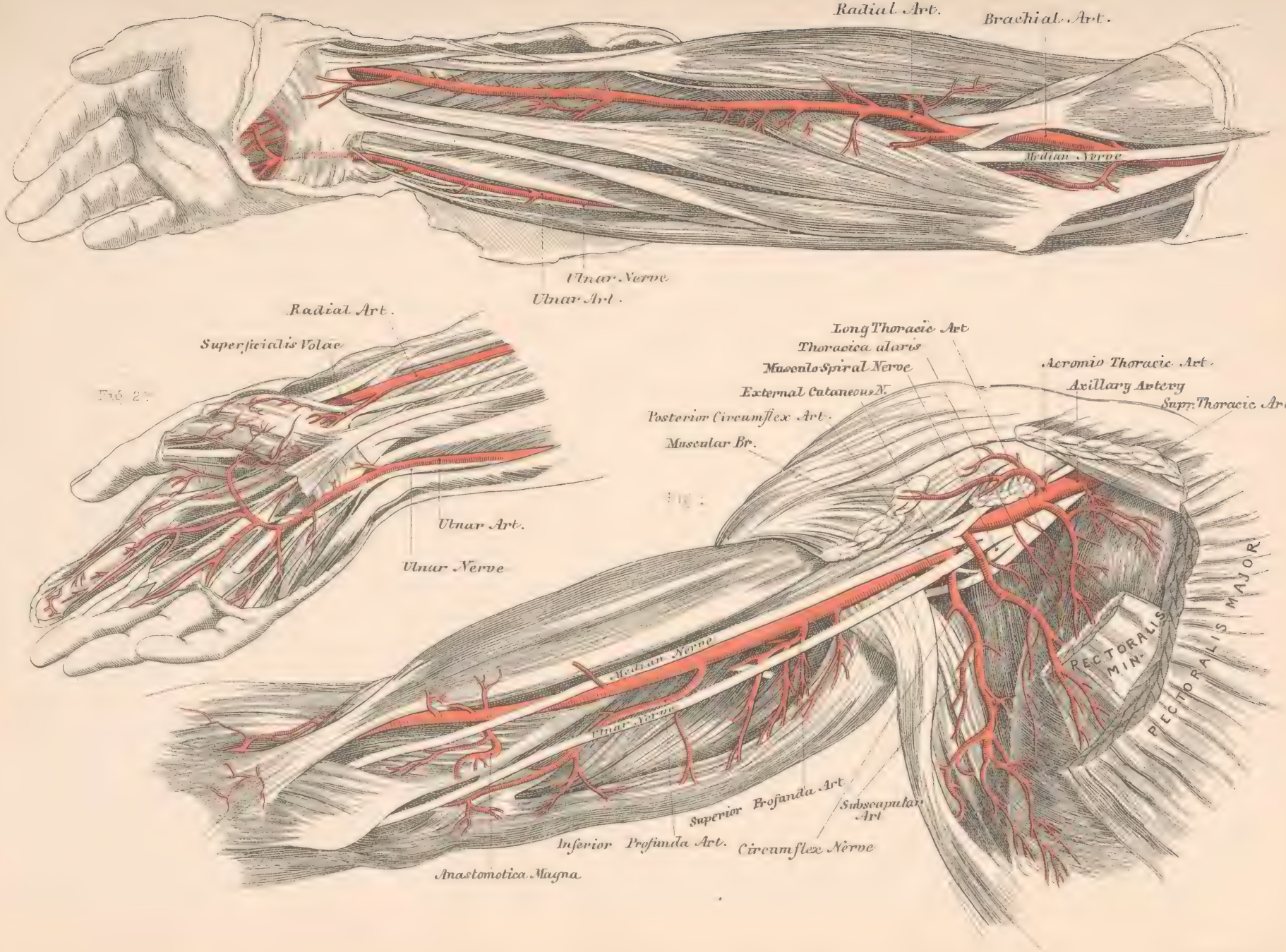
[1] The term "island-formation" implies that the trunk of the vessel illustrating its use has divided into two branches, which, however, instead of remaining distinct, reunite a short distance beyond the point of division.

[1] Surg. Anat. of Arteries, 180.

EXPLANATION OF PLATE LXV.

Fig. 1. The axillary and brachial arteries.

Fig. 2. The radial and ulnar arteries.



T. Sinclair & Son Lith.

Ligation of the Brachial Artery.—For the *upper third* of the arm, the limb is rotated outward and abducted. An incision is made two inches long, using the inner (ulnar) border of the Coraco-Brachialis muscle as a guide. The integument is thin, and the basilic vein is sometimes found lying beneath it upon the brachial fascia. After dividing the fascia, the artery and venæ comites are exposed. The internal cutaneous and ulnar nerves lie to the inner side, and the median nerve to the outer side.

For the *middle third* of the arm, the limb being held as before, an incision of the same length is made along the inner (ulnar) margin of the Biceps muscle. The remaining steps of the operation are those above given. The median nerve is seen lying upon or crossing the artery. It may, however, lie beneath it. The nerve should be drawn inward, the muscle outward.

The profunda artery, when enlarged, may be mistaken for the brachial. It is important to remember that the latter vessel lies nearer to the humerus than the former, and the operator should continually work toward rather than away from the shaft of the bone.

This vessel was the subject of a traumatic aneurism in a mason who had received a severe blow over the region of the Deltoid muscle, fracturing the humerus. The man died of hemorrhage due to the bursting of the aneurism.[1]

At the *lower third* of the vessel the inner edge of the Biceps tendon serves as a guide. The artery is reached after dividing the brachial aponeurosis, the median nerve lying well to the inner side. The relation which the artery here holds to the median basilic vein is important. The vein lies over the artery and parallel to it, and in the operation of phlebotomy the artery has been frequently wounded.

At the *elbow* the artery may be reached by an incision extending two inches and a half along the inner margin of the median basilic vein, about one inch above the epitrochlear process, and thence downward and outward along the radial border of the Pronator Radii Teres. After dividing the ante-brachial fascia and the semilunar slip going to it from the Biceps muscle, the Biceps tendon is exposed. The artery is found lying to the inner side of the tendon. The median nerve lies to the inner side of the artery, but is more superficial.

The *collateral circulation* is established as follows:—

Above the Superior Profunda	Superior Profunda	Anterior Circumflex.
Below the Superior Profunda	Superior Profunda	Recurrent branches of the Radial, Ulnar, and Interosseous arteries.

THE RADIAL ARTERY.

The Radial Artery, although the smaller of the two branches arising at the termination of the brachial artery, is the direct continuation of that vessel. It is directed a little obliquely outward at the region of the neck of the radius, but soon becomes vertical, and descends along the anterior aspect of the forearm to the wrist, at which point it turns between the styloid process of the radius and the scaphoid bone to reach the back of the carpus. It thence passes through the first (occasionally the second) interosseous space to the palm, where it joins the ulnar artery in forming the deep palmar arch.

On the forearm the vessel is superficial, save at its upper two-thirds, where it is slightly overlapped by the Supinator Longus muscle. The vessel rests upon the Supinator Brevis and the fibres of insertion of the Pronator Radii Teres, as well as upon the Flexor Longus Pollicis and the thin radial edge of the Flexor Sublimis Digitorum.

To the inner (ulnar) side lie the middle third of the Pronator Radii Teres and tendon of the Flexor Carpi Radialis for the lower two-thirds of the forearm, and to its outer (radial) side lie the tendon of the Biceps muscle, and the Supinator Longus. At about the middle third of its course, it has the radial nerve to its outer (radial) side. At its distal third, the vessel lies superficially between the tendons of the Supinator Longus and Flexor Carpi Radialis muscles.

At the wrist the artery winds around the outer border of the radius to reach the radial border of the forearm, where it descends vertically on the external lateral ligament to the outer side of the radial extensors and beneath the extensors of the thumb. It then becomes superficial, and is contained within a triangular space defined laterally by the Extensor Secundi Internodii Pollicis, and medianly by the Extensor Primi Internodii Pollicis.

The radial artery is accompanied by venæ comites. Some filaments of the external cutaneous nerve pierce the fascia beneath the lower part of the artery, which they accompany to the back of the carpus.

Ligation of the Radial Artery.—A line drawn from the middle of the bend of the elbow to a point midway between the styloid process of the radius and the tendon of the Flexor Carpi Radialis corresponds nearly to the position of the radial artery.

The vessel can be secured by ligature at its upper and lower portions.

The *upper portion.* An incision three inches in length in the direction of the above line beginning one inch below the bend of the elbow. Branches of the median vein are to be avoided, the antebrachial fascia divided, and the Supinator Longus and Pronator Radii Teres muscles drawn apart. The artery and nerve lie in the interspace. The nerve, however, lies toward the radial border, and need not be seen. The *venæ comites* are carefully separated, and the needle passed from either side.

[1] Portal, Anatomie Médical, iii. 236.

The *lower portion.* The artery lies superficially between the tendons of the Supinator Longus and of the Flexor Carpi Radialis. The nerve lies to the lateral (outer) side. When the vessels are known to be enlarged, care should be taken not to confound the radial artery with the superficialis volæ.

The artery can be secured as it crosses the bottom of the space between the tendon of the Extensor Secundi Internodii Pollicis and the sheath containing the tendons of the Extensor Primi Internodii Pollicis and the Extensor Ossis Metacarpi Pollicis. An incision one inch and a half in length is made obliquely across this space. The artery is easily detected lying at the base.

According to Butcher,[1] "In wounds of the radial artery on the back of the forearm, the lower end retracts into the lax tissue lodged in the triangular space, the walls of which are formed on the one side by the Extensor Ossis Metacarpi Pollicis and the Extensor Primi Internodii Pollicis, and on the other by the Extensor Secundi Internodii Pollicis. The way this difficulty is to be met, is by cutting down on the radial artery, just before it dips down to form the palmar arch. It must be remembered, however, that it is covered in by a very dense fascia, which will require to be freely slit on a director. A large vein and a considerable branch of the radial nerve run superficial to the artery in this part of its course, and must be avoided."

Holden[2] states that the line of the superficial palmar arch crosses the palm at about the junction of the upper with the lower two-thirds, that is, in the line of the base of the walls of the thumb separated widely from the fingers.

The artery near the wrist, before it turns over the styloid process, may be separated from the bone by a bursa.[3] The vessel thus situated may become unduly prominent, and transmit its pulsation to the bursa and the surrounding parts. Sir Astley Cooper mentions an instance of ligation of the vessel by an incautious operator who mistook the misplaced artery for an aneurism.

The branches of the radial artery are as follows:—

A. In the forearm.
- (*a*) Radial Recurrent.
- (*b*) Anterior Carpal.
- (*c*) Superficialis Volæ.
- (*d*) Muscular.

B. Behind the wrist.
- (*e*) Posterior Carpal.
- (*f*) Metacarpal (first dorsal interosseous).
- (*g*) Dorsalis Pollicis.
- (*h*) Dorsalis Indicis.

C. In the hand.
- (*i*) Princeps Pollicis Arteria.
- (*j*) Radialis Indicis.

(*a*) The *radial recurrent* artery arises from the outer side of the main vessel at the bend of the elbow. It curves outward and upward with the convexity of the curve downward, to ascend along the groove between the Supinator Longus and the Brachialis Anticus. It rests upon the Supinator Brevis, and sends branches to that muscle as well as to the origins of the radial extensors and to the Extensor Communis Digitorum. It anastomoses with the superior profunda artery.

(*b*) The *anterior carpal* artery is a slender, constant branch arising from the radial artery at the level of the lower edge of the Pronator Quadratus. It passes inward to form with the junction of the anterior carpal branch a transverse arch across the line of the inferior radio-ulnar articulation. It sends branches to the Pronator Quadratus, to the periosteum of the radius and ulna, and to the inferior radio-ulnar articulation.

(*c*) The *superficialis volæ* arises at the level of the styloid process of the radius. It descends vertically across the annular ligament to reach the ball of the thumb, to the muscles of which it is in the main distributed. Its terminal branches lie beneath the palmar aponeurosis, and anastomose with the analogous branches of the superficial ulnar artery to form the superficial palmar arch. According to Sappey, this artery supplies the first two lumbrical muscles.

(*d*) The *muscular* branches supply contiguous muscles of the forearm, and the *nutrient* branch.

(*e*) The *posterior carpal* artery is larger than the preceding. It arises from the radial vessel near the inter-carpal articulation to the outer side of the Extensor Carpi Radialis Longior. It passes transversely across the first row of carpal bones beneath the tendon of the extensors of the thumb and finger, and forms with a branch of the ulnar an arch whose concavity is forward. Branches arise from the arch both above and below. Those above are slender and are distributed to the dorsum of the carpus, the radio-carpal articulation, and to the skin, and anastomose with the anterior interosseous. Those below the arch are larger, and perforate the Dorsal Interosseous muscles to join the deep palmar arch.

(*f*) The *metacarpal* (first dorsal interosseous) arises to the outer side of the Extensor Secundi Internodii Pollicis above the first interosseous space. It lies upon the second interosseous space, anastomoses with the digital branches of the superficial palmar arch, and supplies branches to the index and middle finger.

(*g*) The *dorsalis pollicis* frequently arises from the radial just prior to the vessel perforating the first

[1] Surgery, 407. [2] Landmarks, 120.
[3] Wm. Coulson, London Med. Journ., 1851, 884.

interosseous space. It supplies the dorsum of the metacarpal bone of the thumb.

(*h*) The *dorsalis indicis* is a small branch which supplies the dorsum of the index finger, and sends branches to the Abductor Pollicis.

(*i*) The *arteria princeps pollicis* lies between the First Dorsal Interosseous and the deep head of the Flexor Brevis Pollicis or the Adductor Pollicis. It passes thence along the ulnar border of the thumb to the insertion of the Flexor Brevis Pollicis, where it anastomoses with the dorsalis pollicis, and is distributed to the side, front, and back of the thumb.

(*j*) The *radialis indicis* descends between the Abductor Pollicis and the First Dorsal Interosseous muscle. It passes along the radial border of the index finger. Its terminal branches anastomose with the vessel on the ulnar border of the finger.

The entire arterial supply of the thumb and the index finger is remarkable for the variety displayed in the arrangement of the vessels, which present for a common feature an origin from the radial artery immediately prior to its transit from the dorsum to the palm of the hand.

The above description is the one followed essentially by the English, and by Luschka among the German writers. The last three arteries occasionally arise from a common trunk, according to French writers. Henle describes the arteria princeps pollicis and the radialis indicis as one trunk.

The *deep palmar arch* is the result of the union between the continuation of the radial artery in the palm and the communicating branch of the ulnar. The curve of the arch is convex distally, and rests upon the second, third, fourth, and fifth metacarpal bones, directly below their proximal extremities, and upon the Palmar Interosseous muscles. It is covered by the tendons of the flexor muscles, and in part by the muscles of the ball of the thumb and those of the fifth finger. It is in intimate relation with the Adductor Pollicis.

The branches of the deep palmar arch are as follows:—

(*a*) Ascending (recurrent).
(*b*) Palmar interosseous.
(*c*) Perforating.

(*a*) The small *ascending* branches are six in number. They pass upward from the concavity of the arch to supply the anterior aspect of the carpus and inosculate with the terminal branches of the anterior carpal arteries.

(*b*) The *palmar interosseous* branches, usually three in number, pass downward from the convexity of the arch upon the corresponding muscles of the same name, and anastomose with the digital branches of the superficial arch, at the level of the metacarpophalangeal articulation. They send small branches to the interosseous muscles, to the periosteum of the metacarpal bones, to the Adductor Pollicis and Lumbrical muscles, and to the web of the fingers.

(*c*) The *perforating* arteries, generally three in number, pass between the proximal ends of the three median interosseous spaces, to reach the dorsum of the hand, where they anastomose with the dorsal interosseous arteries.

Variations.—The radial artery, when of "high origin," may give off the subscapular and other branches normally derived from the axillary and brachial arteries. At the elbow it is apparently modified by the position of the slip from the tendon of the Biceps muscle. It may be contorted near the slip, or may pierce it; or it may curve abruptly forward as it passes from the level of the Supinator Brevis to that of the Pronator Radii Teres. It may send off at the same place an aberrant muscular twig; or a superficial branch may pass distally on the deep fascia in company with the median vein. It may yield the interosseous artery. When the radial is absent, or when it terminates at a point proximal to the wrist, its place may be supplied by the normally constituted interosseous artery. The superficialis volæ may be rudimentary, and may not contribute to the formation of the superficial palmar arch. The radial may end in the integument at the wrist, the ulnar taking its place in forming the palmar arches.

Perhaps the most important of the variations relate to the peculiarities of *the radial pulse.* The pulse is not of necessity absent when the radial artery is absent, for the place of that vessel can be taken by an unusually well-developed superficialis volæ of "high origin." The radial artery may, soon after its origin, wind round the radius and descend the back of the forearm, when the superficialis volæ may yield "*the radial pulse.*" The abnormal vessel is always smaller than the normal one. It is evident that, should this anomaly be found in both forearms, and should the radial pulsation be relied upon, very erroneous impressions would be received by the observer as to the condition of the circulation. In the rare instances in which the normal radial artery is accompanied by the superficialis volæ, the anomaly of a *double radial pulse* is presented.

Under the name of the *median artery* is described an aberrant branch of the radial artery that follows the course of the median nerve to the palm, where it may join the superficial palmar arch, or may terminate by direct anastomosis with the ulnar artery.—Instead of piercing the first, the radial artery may pierce the second inter-metacarpal space.—The recurrent branch may be larger than usual, and its anastomosis with the superior profunda be so marked as to suggest the hypothesis that an obstruction had existed in the

brachial artery for a sufficient length of time to establish a *collateral circulation.*

THE ULNAR ARTERY.

The Ulnar Artery, the larger of the two divisions of the brachial, is curved a little obliquely downward and outward toward the inner side of the forearm, through its upper third; it is then directed vertically downward to terminate in the palmar arch. The artery is divided for convenience into three portions: (1) As it lies in the forearm. (2) As it lies at the wrist. (3) As it lies in the hand.

(1) *The ulnar artery in the forearm.* The vessel at its origin is covered by the flexor muscles which arise from the epitrochlea, except the Flexor Carpi Ulnaris. It here lies beneath the Flexor Sublimis Digitorum and upon the Flexor Profundus Digitorum, the tendons of the Brachialis Anticus and Biceps muscles, and is separated from the median nerve which lies to its radial side by the deep head of the Pronator Radii Teres. As it descends the forearm it is covered by the Flexor Carpi Ulnaris until it reaches the junction of the upper and middle thirds, where it becomes superficial, and lies in a depression between the Flexor Carpi Ulnaris and the Flexor Sublimis Digitorum. Behind it lies the Flexor Profundus Digitorum. The ulnar nerve, which lies far to the inner side above, gradually approaches the artery, and, from the middle of the forearm, lies closely to its ulnar side and continues with it into the palm.

(2) *The ulnar artery at the wrist.* At the wrist the artery passes in front of the annular ligament, and lies to the radial side of the pisiform bone, which, in a measure, protects it. In front of the artery lies a thin layer of fibrous tissue, extending from the annular ligament inward to the palmar fascia.

(3) *The ulnar artery in the palm.* Within the palm the ulnar artery divides into two branches: (*a*) *the superficialis volæ*, the continuation of the main course of the artery, which passes outward between the Palmaris Brevis and the muscles of the little finger, and beneath the Palmaris Longus, to anastomose with the superficial volar of the radial artery; and (*b*) the *communicating branch* which reaches the deeper structures of the palm, to the radial side of the muscles of the little finger or between them.

The branches of the ulnar artery include the following:—

A. In the forearm.
- (*a*) Anterior Ulnar Recurrent.
- (*b*) Posterior Ulnar Recurrent.
- (*c*) Common Interosseous.
- (*d*) Muscular branches.

B. At the wrist.
- (*e*) Posterior Ulnar Carpal.
- (*f*) Anterior Ulnar Carpal.

C. In the hand.
- (*g*) Deep or Communicating.

(*a*) The *anterior ulnar recurrent* artery arises from the ulnar at the upper part, passes obliquely downward and inward to reach the Brachialis Anticus muscle, upon which it ascends to reach the front of the epitrochlea, where it inosculates with the anastomotica of the brachial. It is at first covered by the Pronator Radii Teres, and later lies in the groove between this muscle and the Brachialis Anticus, and sends branches of supply to both muscles as well as to the Flexor Carpi Radialis and the Flexor Sublimis Digitorum.

(*b*) The *posterior ulnar recurrent*, larger than the preceding, and often found arising from the same trunk with it, passes inward on the Flexor Profundus Digitorum. It curves upward behind the epitrochlea, where it inosculates with the anastomotica and the inferior profunda. This vessel is at first covered by the flexor muscles arising from the epitrochlea, and at the median side of the elbow it passes between the two heads of the Flexor Carpi Ulnaris, at which point it lies in front of the ulnar nerve, and sends twigs to the origin of the muscles arising from the epitrochlea, to the ulnar nerve, and to the skin.

(*c*) The *common interosseous* artery, the largest of the ulnar branches, usually arises from the posterior surface of the main vessel about an inch below the tuberosity of the radius. It is exposed in dissection by separating the Flexor Sublimis Digitorum from the Flexor Profundus Digitorum. The artery, with an accompanying vein, lies deep in the interosseous space. It descends for about an inch upon the interosseous membrane, and divides into two branches, an anterior and a posterior.

The *anterior interosseous* branch continues down the forearm upon the interosseous membrane, between the Flexor Profundus Digitorum and the Flexor Longus Pollicis, in order to reach the proximal border of the Pronator Quadratus, behind which it passes, and then pierces the lower portion of the interosseous membrane, to anastomose with the terminal branches of the posterior interosseous branch and to supply the dorsum of the carpus. It here joins the descending branches of the posterior ulnar carpal branch. The most important branches of the anterior interosseous are the *perforating*, which pierce the interosseous membrane to yield twigs to the deep-seated muscles of the back of the forearm; the

artery for the median nerve, which accompanies the fibres of the median nerve as far as the palm; the *muscular* branches which supply the Flexor Longus Pollicis, the Flexor Profundus Digitorum, and the Pronator Quadratus; the *nutrient arteries* for the shafts of the ulna and occasionally the radius; and *an anastomosing branch* that descends beneath the Pronator Quadratus, and, after supplying the parts in front of the carpus, anastomoses with the anterior carpal branches of both the radial and the ulnar arteries.

The *posterior interosseous* artery, often the larger of the two branches of the common interosseous, passes backward between the oblique ligament and the upper border of the interosseous ligament. As it enters the posterior aspect of the forearm, it is received between the lower border of the Supinator Brevis and the Extensor Carpi Ulnaris. It descends below the superficial and the deep layer of muscles to the lower part of the forearm, where it joins the posterior division of the anterior interosseous artery. The posterior interosseous artery gives off an ascending branch, the *interosseous recurrent*, which lies upon the Supinator Brevis as far as the head of the radius, and afterward upon the Anconeus to the epicondyle, where it anastomoses with the radial recurrent artery. It gives branches to the muscles in the neighborhood of the elbow-joint and to the skin.

(*d*) *Muscular branches.* The muscular branches supply chiefly the muscles of the forepart of the forearm. The perforating branches, when not branches of the anterior interosseous, arise directly from the ulnar artery.

(*e*) The *posterior ulnar carpal* arises from the ulnar artery, about an inch and a half above the pisiform bone, and winds backward between the ulna and the Flexor Carpi Ulnaris to reach the back of the wrist, where it terminates in branches which anastomose with the posterior radial carpal artery to form the *posterior carpal arch*.—The *second* and *third* interosseous arteries, according to Quain, are derived from this arch. They descend upon the fourth and fifth interosseous spaces, and receive the perforating branches of the deep palmar arch. They also send minute branches along the fifth metacarpal bone.

(*f*) The *anterior ulnar carpal* is a small twig which arises opposite the lower border of the Pronator Quadratus, and anastomoses with the branches of the anterior radial carpal artery.

(*g*) The *deep* or *communicating* branch, the terminal branch of the artery, passes between the pisiform bone and the unciform process of the unciform bone, and thence between the Abductor Minimi Digiti and the Flexor Brevis Minimi Digiti, and turns forward to join the radial artery. This union completes the *deep palmar arch.*

The Superficial Palmar Arch. The superficial palmar arch is the result of union between the continuation of the trunk of the ulnar artery across the palm, under the name of the *superficial palmar artery*, and the superficialis volæ of the radial. It lies beneath the palmar aponeurosis and above the flexor tendons and the digital branches of the median nerve.

The branches of the superficial palmar arch are called the digital arteries.

The *digital arteries* are generally four in number; they arise from the convexity of the deep palmar arch. Each artery divides at the web of the finger to supply the lateral borders of the adjacent fingers, so that the digital artery toward the radial border of the hand supplies the ulnar border of the index and the radial border of the middle finger. The next in order supplies the ulnar border of the middle finger, and the radial border of the ring finger; while the next supplies the ulnar border of the ring, and the radial border of the little finger. The digital artery on the ulnar border of the hand is an exception to this rule. It does not bifurcate, but terminates only on the ulnar border of the little finger. Sometimes this vessel is a branch of the ulnar at a higher point than the palmar arch.

According to some authorities, minute vessels arise from the concavity of the superficial palmar arch, and are directed backward. The bifurcation of the digital artery ordinarily takes place at a point midway between each interdigital space and the more anterior of the two transverse palmar folds.

The Ligation of the Ulnar Artery.—The ulnar artery can be reached at its upper portion by cutting across the superficial flexor mass. By many surgeons it is deemed best to secure the brachial in case of any necessity for arresting hemorrhage at this portion of the ulnar artery. At its lower portion the vessel is more accessible, and can be exposed by making an incision through the skin and fasciæ, one-and-a-half inch long, in the depression between the Flexor Sublimis Digitorum and the Flexor Carpi Ulnaris muscles, and by drawing the Flexor Carpi Ulnaris to the inner side. The ulnar nerve lies to the ulnar side of the artery. Should the above-named intermuscular depression be obliterated by the swollen condition of the limb, the position of the pisiform bone will serve the purpose of guiding the operator to the vessel. Thus an incision, one-and-a-half inch in length, may be made extending upward along a line drawn from this bone.

In order to make the ulnar artery in the forearm more superficial, Malgaigne[1] recommends that, before the first

[1] Revue Méd.-Chir., tom. ii. 160.

incision is made, the fingers be forced markedly backward, and so retained during the different steps of the operation. This causes the Flexor Carpi Ulnaris muscle to retreat inward and backward, so that the artery, which in the normal position of the parts is partly concealed by the muscle, is transferred to a more anterior plane at the same time that the Flexor Profundus Digitorum, on which the artery lies, is greatly raised.—The artery at the wrist may be displaced anteriorly by an enlarged bursa.

The *collateral circulation*, after ligation, is established thus:—

Recurrent Ulnar artery + Recurrent Radial and Recurrent Interosseous with Inferior Profunda and Anastomotica.

Variations.—The ulnar artery may have a "high origin," when it may be one of the subdivisions of the brachial, or, in its absence, of the axillary; but its development as an aberrant branch, from the brachial or long thoracic, is a more common variation. When thus aberrant, it runs superficially to the forearm to supply the region of the normally disposed vessel, and tends to follow the course of the superficial veins and nerves. It may thus run in a sheath with the basilic vein and the internal cutaneous nerve. Or it may lie *behind* the epitrochlea of the humerus in company with the ulnar nerve.—The most important variety of any branch of the ulnar occurs in the common interosseous artery. The common interosseous is never a branch of the ulnar when this vessel has a high origin, but is often the continuation of the brachial artery.—The brachial may end in three vessels instead of two, the third vessel in all instances being the common interosseous.—The median artery may go to the palm and take the place of the ulnar and the radial branches. It may unite these branches or aid in forming the superficial palmar arch. A number of five-fingered quadrupeds retain these manal terminations of this artery. The median artery may lie superficial to the median nerve at the side of the tendon of the Palmaris Longus. —The recurrent branches are subject to many unimportant variations. For the most part these consist of slight deviations of the vessels as they—in association with the branches of the inferior profunda and the anastomotica—form a coarse network behind and at the sides of the elbow-joint. Some writers apply the term *rete* to this kind of anastomosis.—A transverse branch may unite the ulnar with the radial artery at the lower third of the forearm. — The superficial palmar arch may be absent, or may be smaller than usual, or it may, by its size or duplication, measurably take the place of the deep arch. The digital arteries, while varying in origin from the palmar arches and the arteries of the metacarpus, are singularly constant in their positions at the sides of the fingers.

THE DESCENDING THORACIC AORTA.

The Thoracic Aorta is that portion of the aorta lying between the aortic arch and the Diaphragm. At first lying to the left side of the third dorsal vertebra, it soon inclines toward the front of the vertebral column, and, at the aortic orifice of the Diaphragm, lies directly in the median line. In front is the root of the left lung, and at the upper portion is the œsophagus. Behind are the vertebral column and the small azygos vein. To the right side lie the œsophagus, the thoracic duct, and the great azygos vein. Towards its termination, the œsophagus, and the left pleura and corresponding lung, lie a little to the left side of the aorta. The aorta presents a curve answering to that of the vertebral column, and is slightly convex to the right side.

The branches of the descending thoracic aorta are—

(*a*) Pericardial.
(*b*) Bronchial.
(*c*) Œsophageal.
(*d*) Mediastinal.
(*e*) Intercostal.

(*a*) The *pericardial* arteries are several minute branches which are distributed, as the name indicates, to the pericardium.

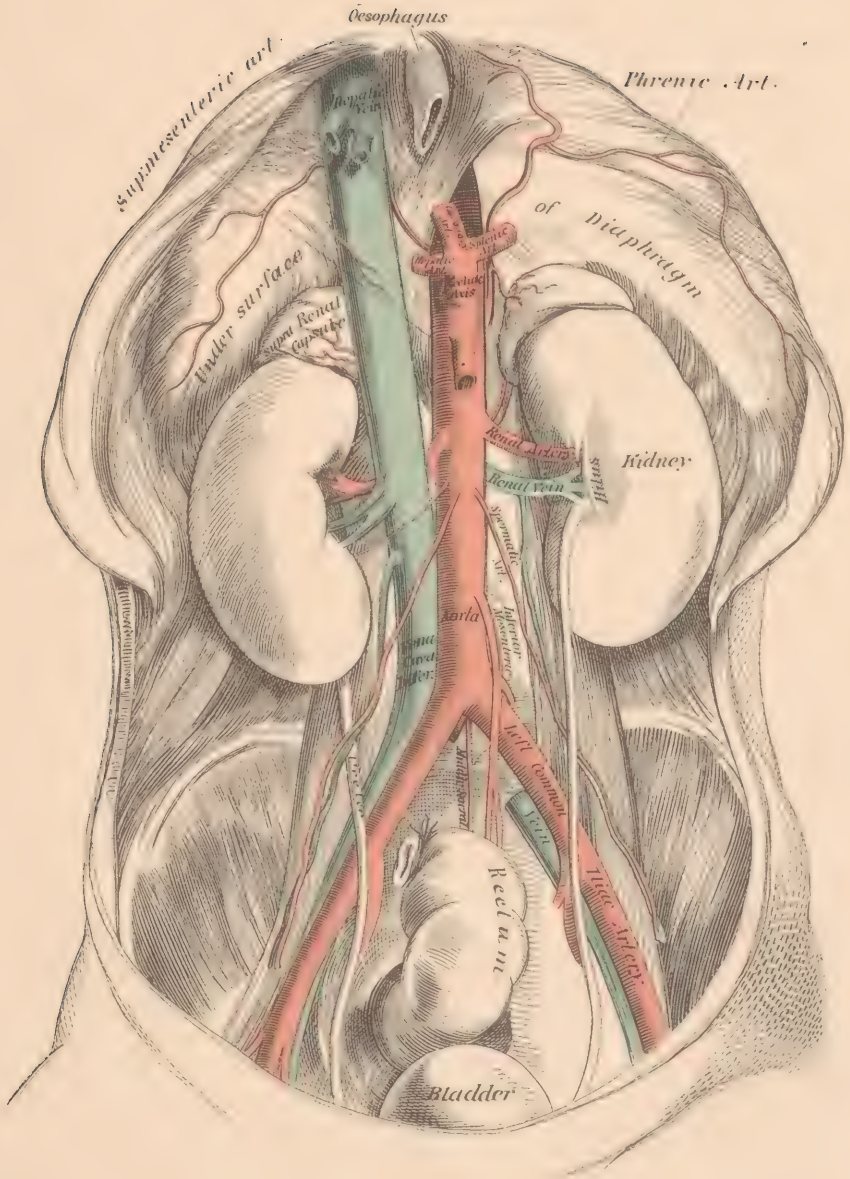
(*b*) The *bronchial* branches are the nutrient vessels of the lungs. They are from two to three in number, and arise from the anterior aspect of the aorta. The right bronchial artery may arise, not from the descending aorta, but from either the first intercostal, the internal mammary, or the inferior thyroid, or, sometimes, by a common trunk with the upper left bronchial artery. The left bronchial arteries are usually two in number, the upper arising from the beginning of the thoracic aorta. The arteries are directed to the posterior surface of the bronchial tubes, and accompany them to their terminal subdivisions.

(*c*) The *œsophageal* arteries embrace from three to six minute vessels. They anastomose above with the inferior thyroid, and below with the ascending branches from the phrenic and gastric arteries.

(*d*) The *mediastinal* branches arise from the front

EXPLANATION OF PLATE LXVI.

The abdominal aorta and its branches, the common iliac arteries, and the inferior vena cava.



T. Sinclair & Son, Lith.

of the aorta, and supply the connective tissue of the posterior mediastinum.

(*e*) The aortic *intercostal* arteries, unlike the preceding branches of the descending aorta, are not distributed to the viscera, but to the walls of the chest; they are from nine to ten in number, the first and the second intercostal spaces being supplied by the first intercostal artery. They arise from the sides of the thoracic aorta, the right branches being longer than the left, since they must cross the dorsal vertebræ to reach the intercostal spaces of the right side.

The arteries for the upper spaces ascend somewhat obliquely outward; those for the middle and lower spaces are directed outward and slightly downward.

Each artery, as it passes to the angle of the rib, divides into two branches, an anterior or true intercostal, and a posterior or dorsal.

The *anterior* branch gains its corresponding space about midway between the costal borders. It thence lies within the groove along the under border of the rib. At the point where this groove disappears, the artery regains its first position in the middle of the space, but soon terminates by anastomosing with the internal mammary artery. The vessel at first lies upon the Internal Intercostal muscle, and subsequently between the two Intercostal muscles. Just at its entrance between the muscles it gives off the *supracostal* branch. This is a small vessel, which gains the upper border of the rib immediately below, along which it runs for a short distance, and is finally distributed to the periosteum and to the external surface of the thorax. It supplies the Intercostal muscles, and sends minute branches to the Pectoralis Major and Pectoralis Minor, the Serratus Magnus, the External Intercostal muscles, and to the digitations of the abdominal muscles.

The *posterior* or dorsal branch passes to the inner side of the anterior costo-transverse ligament, and sends a branch through the intervertebral foramen in company with the posterior branch of the corresponding spinal nerve. This supplies the spinal cord and the interior of the vertebral canal. A second branch passes backward, and is lost in the deep-seated muscles. A few twigs supply the integument.

Remarks.—English writers describe under this head an *internal* branch which is directed toward the spinous process, and an *external* branch which passes under the Longissimus Dorsi muscle, and which becomes superficial between that muscle and the Sacro-Lumbalis.

The above presents the general distribution of the aortic intercostal vessels. It may be remarked that such of these vessels as cross the vertebral column supply, by minute twigs, the bodies of the vertebræ and the intervertebral disks. The third intercostal artery anastomoses with the first intercostal. The third vessel on the right side often supplies the corresponding bronchial artery. The lower intercostal arteries pass behind the pillars of the Diaphragm. They supply the origins of the abdominal muscles and the costal origin of the Diaphragm. They anastomose with the terminal twigs of the internal mammary, with the epigastric, and with the phrenic arteries. In the female, branches of the third, fourth, fifth, and sixth intercostal arteries go to the mammæ. The seventh has been seen supplying the sixth as well as its own intercostal space.

The *collateral circulation*, after obliteration of the thoracic aorta by disease or malformation, may, according to Sydney Jones,[1] be sustained as follows:—

First, the internal mammary artery anastomoses with the intercostal arteries, with the phrenic of the abdominal aorta by means of the musculo-phrenic and comes nervi phrenici, and largely with the deep epigastric. Secondly, the superior intercostal anastomoses anteriorly by means of a large branch with the first aortic intercostal, and posteriorly with the posterior branch of the same artery. Thirdly, the inferior thyroid artery effects, by means of a branch of about the size of an ordinary radial, a communication with the first aortic intercostal. Fourthly, the transversalis colli, by means of very large branches, joins the posterior branches of the intercostals. Fifthly, the branches of the subclavian and axillary arteries going to the side of the chest are large, and anastomose freely with the lateral branches of the intercostals.

Variations.—The aorta may lie on the right side of the vertebral column, give off the right subclavian artery, and send branches to the under surface of the right lung; it may contribute a branch to the right kidney.

THE ABDOMINAL AORTA.

The Abdominal Aorta extends from the Diaphragm, opposite the last dorsal vertebra, to the fourth or the middle of the fourth lumbar vertebra, where it ends by dividing into the two common iliac arteries. The vessel is in direct continuity with the descending thoracic aorta, and lies on the left side of the vertebral column. The vena cava, the thoracic duct from its origin, and the azygos vein, lie to the right. In front lie the pancreas, the splenic vein, the third portion of the duodenum, and the peritoneum.

To make pressure upon the abdominal aorta, it is recommended to place the pad of the abdominal tourniquet one to one-and-a-half inch below the umbilicus and slightly to the left, or from this point down to the level of the highest part of the crest of the ilium. This procedure may be an effective adjunct to the

[1] Trans. Path. Soc. London, viii. 1857, 162.

operation of amputation at the hip. It is effected with relative ease in the young and emaciated as compared with the aged or obese.

In emaciated individuals the normal pulsations of the abdominal aorta are so easily detected in palpation of the abdominal parietes as to lead the incautious to mistake them for the pulsations of an aortic aneurism.

Ligation of the Abdominal Aorta.—This vessel can be reached best by the method pursued by James.[1] An incision six inches in length is made, extending from the end of the tenth rib of the left side to a point one inch to the median side of the anterior superior spinous process of the ilium. The abdominal muscles are taken up severally upon a grooved director and divided. The transversalis fascia being reached and divided, the hand is passed between it and the peritoneum, and gently passed inward to the aorta. The sympathetic nerves about it must be carefully separated with the tip of the finger, and the needle passed with a full knowledge of the position of the inferior vena cava to the right of the vessel. The aorta has been ligated eight times, and in every instance without success in saving life. Monteiro, in 1842, ligated the abdominal aorta, the patient surviving ten days; in the remaining cases the patients lived from twelve hours to one to two days.

The *collateral circulation* is established, when this vessel is ligated in dogs, through the deep epigastric and internal mammary arteries. In Murray's[2] case of the ligation of the aorta in man, the patient died in twenty-three hours. An anastomosing vessel between the inferior mesenteric and the left internal iliac artery carried the injecting size which was thrown into the aorta above the ligated point. No other channel of communication between the trunk and the lower limbs was detected.

The branches of the abdominal aorta are both symmetrical and asymmetrical.

The Symmetrical Branches include—

(*a*) Inferior Phrenic.
(*b*) Lumbar.
(*c*) Renal.
(*d*) Supra-Renal.
(*e*) Spermatic.
(*f*) Ovarian.

(*a*) The *inferior phrenic* arteries, two in number, generally arise by a single trunk (although they may arise separately) from the abdominal aorta, just below the aortic orifice of the Diaphragm.

Each vessel passes upward, outward, and forward. The right inferior phrenic lies between the right crus of the Diaphragm, which is behind it, and the inferior vena cava, which is in front, while the left separates the left crus of the Diaphragm from the œsophagus. The vessel finally reaches the Diaphragm, to the under surface of which its branches are for the greater part confined. The two arteries anastomose behind the cordiform tendon. Each vessel divides into an anterior and an external branch. The *anterior* branch passes toward the front of the Diaphragm, where it anastomoses with its fellow of the opposite side, and with the musculo-phrenic branch of the internal mammary artery. The *external* branch passes outward, and anastomoses with the lower intercostal arteries.

Branches are also distributed as follows: A *descending* branch to the supra-renal capsule; an *œsophageal* branch; and a small twig which passes to the coronary ligament of the liver.

Henle describes small branches which perforate the Diaphragm to supply the pericardium. Small branches also pass to the spleen, to the pancreas, and to the wall of the vena cava.

(*b*) The *lumbar arteries* are from four to five in number, and are arranged after the manner of the intercostals. Each vessel arises from near the posterior surface of the abdominal aorta, passes outward across the lumbar vertebræ, and divides into two branches, a posterior and an anterior.

The *posterior* branch represents the dorsal branch of an intercostal artery. Like this, it passes between a pair of transverse processes toward the back, and sends a branch through the intervertebral foramen to supply the spinal cord, the membranes, and the bony surfaces of the vertebral canal. The terminal twigs of the posterior branches are lost in the structures of the loins.

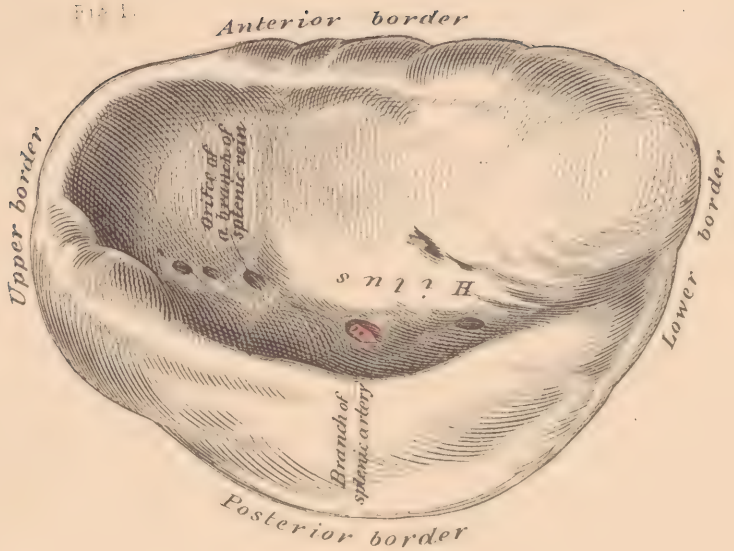
The *anterior* branch corresponds to the artery of the same name in the intercostal series. The upper vessels are crossed by the tendinous arches from which the Psoas muscle arises. Each vessel pierces the Quadratus Lumborum muscle, and is distributed to the abdominal muscles. It anastomoses with the

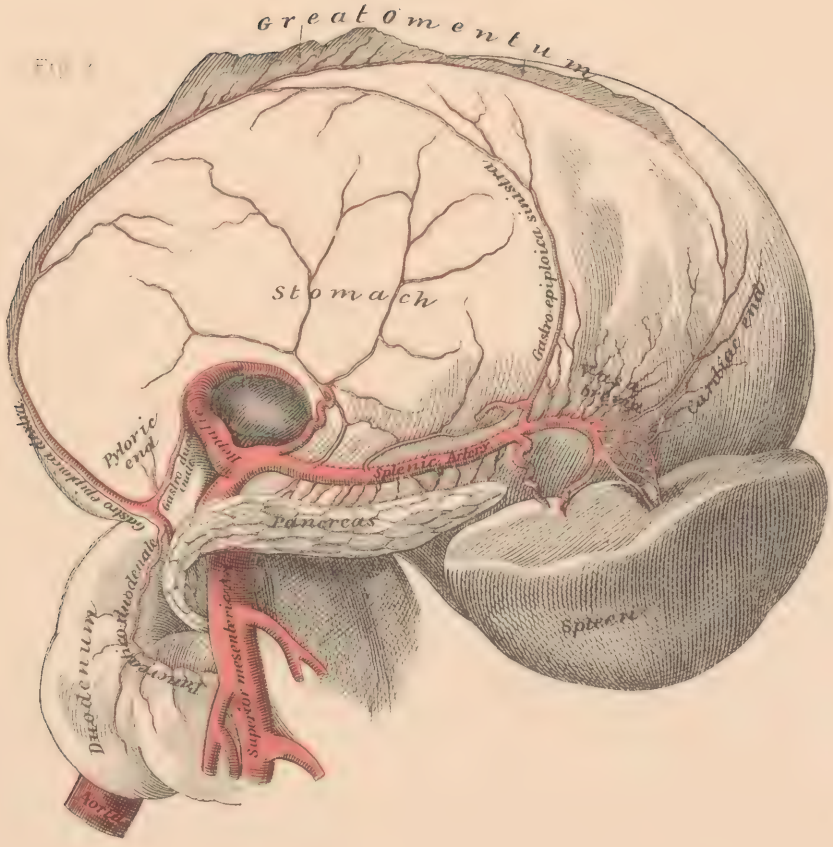
[1] Med.-Chir. Trans., xvi. 1. [2] Lond. Med. Gaz., 1834

EXPLANATION OF PLATE LXVII.

Fig. 1. The spleen, seen from its median surface.

Fig. 2. The arterial supply of the stomach, spleen, and the adjacent parts. The stomach is represented with the greater curvature upward.





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lower intercostal vessels, and sends one branch downward to the ilium, where it joins the circumflex iliac artery. The anterior branch anastomoses with the terminal branches of the deep epigastric and internal mammary arteries.

(*c*) The *renal arteries* are two in number. They arise from the sides of the aorta a little below the origin of the superior mesenteric artery, and pass almost transversely outward to the kidneys. The right vessel is longer than the left by reason of the necessity of crossing the vertebral column. The left passes slightly downward. Each vessel divides into from four to five branches at the hilum of the kidney. On the right side the renal vein lies in front of the artery, but on the left it lies behind it. The number of the renal arteries may be increased to four.

The renal arteries, together with the cœliac axis and the superior mesenteric artery, were found by Ede[1] much contracted in a case of fibroma of the retro-peritoneal space.

(*d*) The *supra-renal arteries* are two small vessels (often branches of the renal) which pass outward to supply the supra-renal bodies and the surrounding fat.

(*e*) The *spermatic arteries* are two in number. They arise from the anterior portion of the abdominal aorta, a little below the position of the renal arteries. The right vessel often arises from the corresponding renal artery. Each vessel passes downward, following at first the course of the ureter of the same side. Near the brim of the pelvis it crosses the ureter at an acute angle, to be directed forward along the course of the common iliac artery, and finally reaches the inguinal canal of its own side, which it enters in company with the vas deferens. It thence becomes tortuous, and is distributed to the testicle; one branch entering the epididymis, and the other the body of the testis.

Each artery sends off minute twigs to the ureter, to the sub-peritoneal connective tissue, to the lumbar lymphatic glands, and, according to Henle, to the fat about the kidney. It anastomoses with the artery of the vas deferens. The right vessel lies in front of the vena cava and behind the sigmoid flexure.

(*f*) The *ovarian arteries* are representatives in the female of the spermatic arteries, and have a similar origin. They are designed chiefly for the ovaries, although a small branch descends the Fallopian tube to the side of the uterus.

Each artery passes outward and downward between the layers of the broad ligament, and enters the ovary at its attached border. A branch may be given off which descends with the round ligament to the groin. Twigs from the main vessel also supply the ureter and the subperitoneal connective tissue.

The Asymmetrical Branches are—

(*a*) Cœliac Axis.
(*b*) Superior Mesenteric.
(*c*) Inferior Mesenteric.
(*d*) Middle Sacral.

(*a*) The *cœliac axis* is a short but robust branch of the abdominal aorta, from one inch to one-and-one-half inch in length. It arises from the vessel as it lies between the crura of the Diaphragm, and is directed forward and slightly to the left. It divides into three branches:—

(1) Coronary.
(2) Hepatic.
(3) Splenic.

(1) The *coronary* artery is the smallest branch of the cœliac axis. It arises from the middle part of the axis, and is at first inclined to the left, but, turning abruptly to the right, it supplies the upper or lesser curvature of the stomach, sending branches upward around the œsophagus, and anastomoses with the pyloric branch of the hepatic artery.

F. A. Balley[1] describes a case of aneurism in the cœliac axis in a man aged thirty-three. The tumor was of the size of a cocoanut, and lay midway between the ensiform cartilage and the umbilicus, and was appended to the aorta as a kind of pouch from which the branches of the axis arose.

Aneurism of the coronary artery rarely occurs. The fact, however, that thirteen cases have been recorded[2] should be borne in mind by practitioners, as the symptoms of the affection closely simulate those excited by gastric cancer or ulceration.

(2) The *hepatic* artery is directed behind the pylorus and toward the right side. It passes near the lobus Spigelii, and enters the gastro-hepatic omentum, soon to divide into two and sometimes into three branches which enter the transverse fissure of the liver in company with the portal vein. The artery lies between the portal vein and the bile-duct. The upper branch, or hepatic artery proper, commonly divides into a right and a left branch. From the right is derived the *cystic* branch which supplies the gall-bladder. The left trunk supplies the left lobe of the liver. The lower branch of the hepatic artery commonly gives origin to the pyloric and gastro duodenal branches.

[1] Amer. Journ. Med. Sci., Jan. 1871, 92.

[1] Med. Times and Gazette, 1862, ii. 626.

[2] M. Villard, Bull. de la Soc. Anatomique, t. xlv. 1870, 273.

The *pyloric* branch is a small artery which joins the coronary. It supplies the upper border of the pylorus. It is sometimes a branch of the gastro-duodenal artery.

The *gastro-duodenal*, about two inches in length, passes downward behind the pylorus at its lower border. It divides into two branches, the gastro-epiploica-dextra, and the pancreatico-duodenalis.

The *gastro-epiploica-dextra* passes along the greater curvature of the stomach, and anastomoses with the gastro-epiploica-sinistra branch of the splenic. It supplies the walls of the stomach, and, by numerous short epiploic branches, the great omentum. A rare form of aneurism affecting this vessel has been described.[1]

The *pancreatico-duodenalis* branch runs along the inner border of the second portion of the duodenum, and sends a branch to the head of the pancreas. It often joins the superior mesenteric by a small branch which runs between the lower margin of the pancreas and the third portion of the duodenum.

TABLE OF THE BRANCHES OF THE HEPATIC ARTERY.

Upper (right) Division.	Branches entering the liver.	
	Cystic.	
Lower (left) Division.	Pyloric.	
	Gastro-Duodenalis.	Gastro-Epiploica-Dextra.
		Pancreatico-Duodenalis.

(3) The *splenic* artery, the largest branch of the axis, is directed to the left. It runs along the entire length of the upper border of the body of the pancreas, and reaches the spleen, to which its terminal branches are distributed. The vessel is wavy and sometimes tortuous, especially in engorgements of the spleen.

The branches of the splenic artery are—

(1) Pancreatic.
(2) Gastro-Epiploica-Sinistra.
(3) Gastric Branches (Vasa Brevia).
(4) Terminal.

(1) The *pancreatic* are numerous small branches which are lost in the substance of the pancreas.

[1] Virchow's Archiv, 1867, 384.

(2) The *gastro-epiploica-sinistra* supplies the cardiac end of the stomach, where it anastomoses with terminal branches of the gastro-epiploica-dextra and those of the coronary. It also supplies the omentum.

(3) The *gastric* (vasa brevia) are numerous small branches which supply the cardiac end of the stomach.

(4) The *terminal branches* are four or five in number, and are received in the spleen at the hilum.

(*b*) The *superior mesenteric artery* is slightly larger than the cœliac axis, and arises below it from the front of the aorta. It supplies the lower part of the duodenum, the jejunum, the ileum, the cæcum, the ascending and the transverse colon. It descends vertically between the pancreas in front and the third portion of the duodenum behind. It enters between the two layers of the peritoneum, which form the mesentery where that membrane joins the transverse mesocolon. It is engaged in the adherent borders of the mesentery at the lower border of the beginning of the jejunum, whence it proceeds obliquely downward and toward the left, to terminate in the ileo-colic artery in the neighborhood of the ileo-cæcal valve. The artery is slightly curved, presenting its convexity toward the left side.

The branches of the superior mesenteric are as follows:—

Branches to the Small Intestine (arise from the convexity of the vessel).	Duodenalis.
	Jejunales et Ileæ.
Branches to the Large Intestine (arise from the concavity of the vessel).	Colica Dextra.
	Colica Media.
	Ileo-Colica.

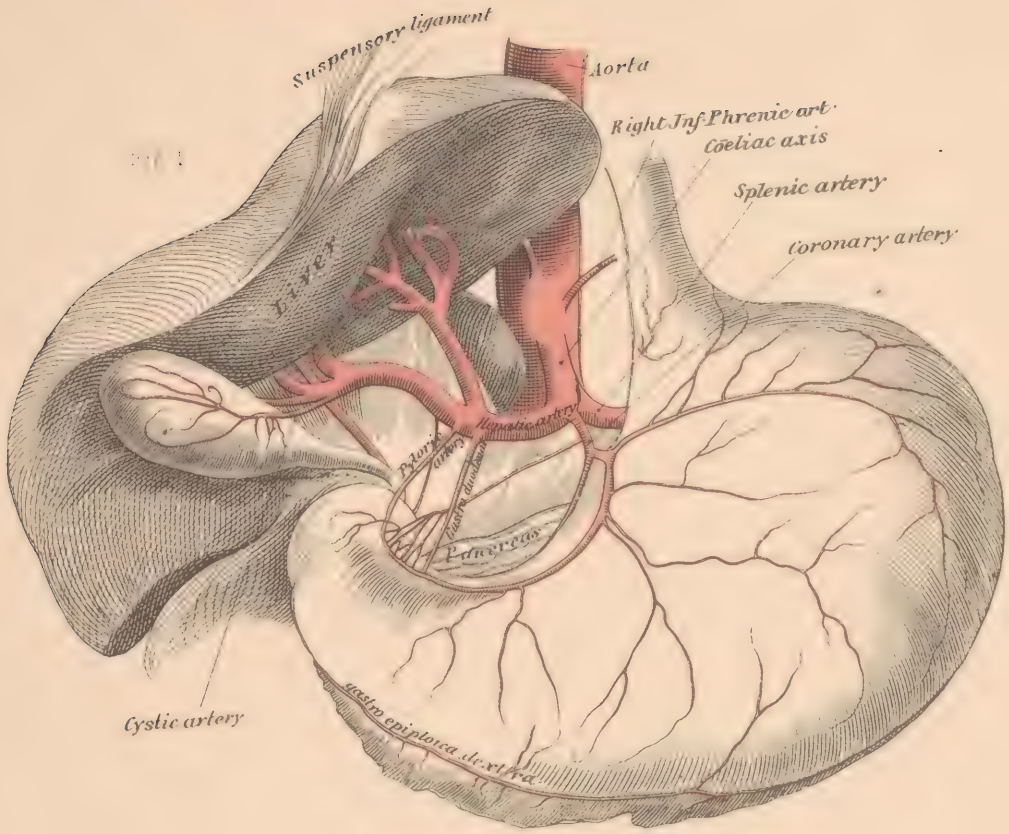
Those for the small intestine comprise the duodenal (inferior pancreatico-duodenalis) and the jejunal and ileal (intestinal branches proper). The *inferior pancreatico-duodenalis* artery runs along the inferior border of the pancreas to join the pancreatico-duodenal branch of the hepatic artery. The *jejunal and ileal* branches vary in number from sixteen to eighteen. Each separate branch soon divides into two, which in their turn divide and inosculate with one another. Following this method of distribution, the

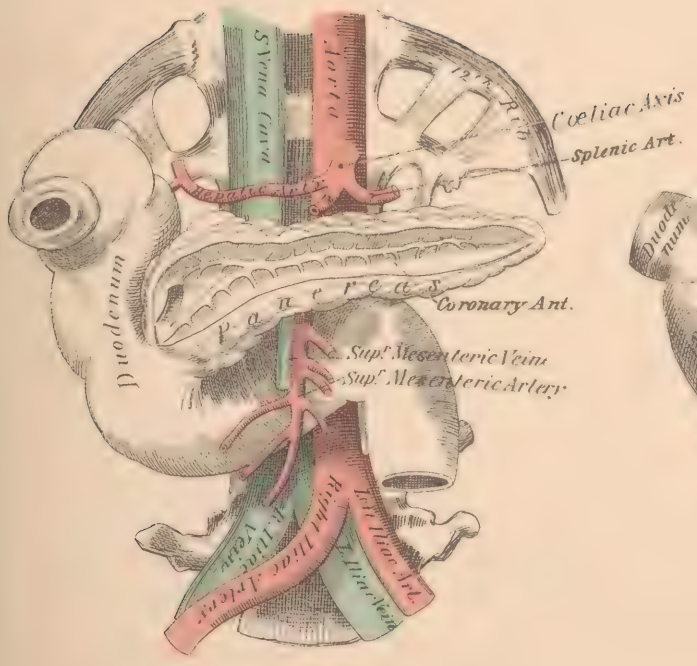
EXPLANATION OF PLATE LXVIII.

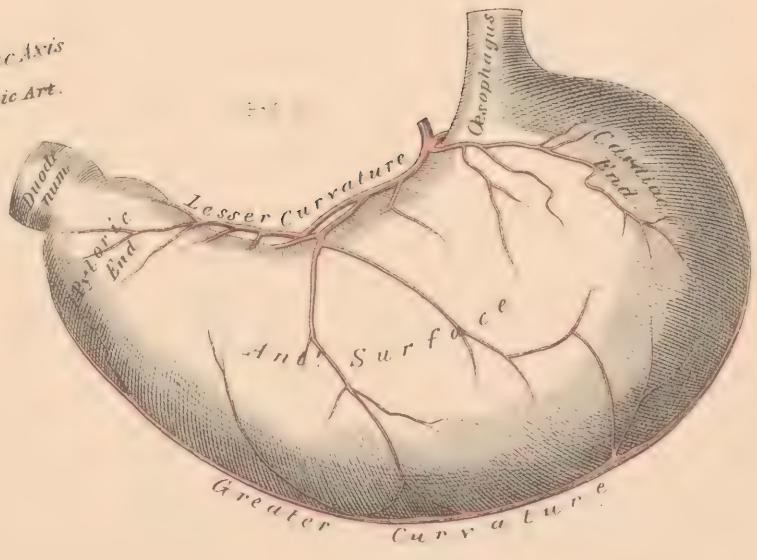
Fig. 1. The stomach, liver, and pancreas, showing the cœliac axis and branches. The branches exhibit the following variations: The hepatic artery sends two branches instead of a single branch to the liver. The pyloric artery and the gastro-duodenalis arise separately from the main trunk of the hepatic artery. The coronary artery arises from the hepatic artery near the origin of this vessel, instead of arising from the cœliac axis.

Fig. 2. A diagram showing the relations of the duodenum and the pancreas to the descending vena cava and the aorta.

Fig. 3. The stomach and its arterial supply.







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branches subdivide into from four to five tiers of mesenteric branches before arriving at the intestines. In addition to the above, the intestinal branches give off to the peritoneum minute twigs, which have received the name of the superficial branches.

The branches for the large intestine are (in addition to the ileo-colic, which is the terminal branch of the main vessel, but conveniently here included) the colica dextra and colica media. The *colica dextra* passes directly outward toward the colon. It divides into two branches, the upper one of which inosculates with the colica media, and the lower with the ileo-colica. The *colica media* resembles the foregoing in its plan of distribution. It ascends vertically to the transverse colon, and inosculates with the colica sinistra of the inferior mesenteric, and with the colica dextra. The *ileo-colica* inosculates with the colica dextra, and sends some branches to anastomose with the terminal branches given off from the convexity. An intermediate branch passes behind the cæcum and supplies that structure, the vermiform appendix, and the ileo-cæcal valve.

The anastomotic loops of the colic branches of the superior mesenteric artery are much fewer and coarser than those of the jejunal and ileal arteries. The network is most conspicuous at the hepatic flexure of the colon.

The relations of the omphalo-mesenteric artery and the superior mesenteric artery may occasionally prove of great importance in determining the nature of *intestinal obstruction*. This fœtal vessel is a branch of the superior mesenteric artery, and is destined to furnish arterial blood to the umbilical vesicle. Under exceptional conditions the omphalo-mesenteric artery persists after the vesicle has been absorbed, and is seen appended to the superior mesenteric artery in the form of a fibrous cord, which may be either attached to the abdominal wall at a point near the umbilicus, or hang free in the abdomen. Or it may lie in the abdominal cavity as a vagrant vessel covered with peritoneum, crossing the abdomen to anastomose with the bloodvessels supplying the fundus of the bladder; vessels which are themselves, doubtless, survivors of the fœtal hypogastric arteries. Both of the above groups of anomalies are sometimes associated with diverticuli of the small intestine.

In a case of fatal intestinal obstruction, recorded by Mr. F. A. Mahomed,[1] a fibrous band, identified as the persistent obliterated omphalo-mesenteric artery, was found after death extending from the abdominal wall, midway between the pubis and the umbilicus, backward toward the right iliac fossa, carrying with it a triangular fold of peritoneum, and held firmly to a branch of the ileo-colic branch of the superior mesenteric artery. It closely embraced a loop of the intestine. In a case reported by Drs. Wood and Hulke,[1] the vessel was found to be pervious as far as the fundus of the bladder.

The superior mesenteric artery has been found by Sabbe[2] to be plugged by an embolus, as a result of which the large intestine became ulcerated, and at a single point perforated. Such a lesion is the more remarkable when the free anastomoses of the branches of this artery with those of the neighboring arteries is recalled.

The root of the vessel tends to present a fixed point for the lower end of the duodenum, and aids indirectly in retaining that viscus in position. It further assists in strengthening the mesentery. See the section upon the Duodenum for its agency in causing lesions of the small intestine.

Aneurism of the superior mesenteric artery has been known to incline to the right side, raising the pancreas before it, and, by pressing upon the ductus communis choledochus, to induce jaundice.[3]

(*c*) The *inferior mesenteric artery* arises from the abdominal aorta, below the superior mesenteric and about an inch above the origin of the common iliacs. It supplies the descending colon, sigmoid flexure, and upper portion of the rectum. It is directed downward and to the right of the sacrum. Its branches are the colica sinistra sigmoid artery, and superior hæmorrhoidal.

The *colica sinistra* inosculates with the colica media and the sigmoid artery. From the loops derived from this union, branches of distribution are supplied to the descending colon.

The *sigmoid* branches unite, in a manner similar to the above, with the colica sinistra and the superior hæmorrhoidal. As the name suggests, its branches of distribution supply the colon at the sigmoid flexure. The sigmoid artery may be a branch of the colica sinistra.

The *superior hæmorrhoidal* descends to reach the posterior surface of the rectum, which structure it supplies. It anastomoses with the middle and inferior hæmorrhoidal arteries.

According to Power,[4] it divides about four inches above the anus, giving one branch to each side of the rectum. These again divide into numerous terminal branches which are distributed around the inferior extremity of the intestine.

(*d*) The *middle sacral artery* is a small median branch placed at the point of bifurcation of the common iliacs.

[1] Trans. Path. Soc. Lond., 1875, 117.

[1] Ibid., 1873, 120.

[2] Bull. de la Soc. Anatomique, t. xlii., 1867, 329.

[3] J. A. Wilson, Med.-Chir. Trans., vol. xxiv., 1842, 221.

[4] Surgical Anatomy of the Arteries.

It descends in the median line upon the last lumbar vertebra and upon the anterior surface of the sacrum to the coccyx, where it anastomoses with the lateral sacral and hæmorrhoidal arteries. It is crossed in front by the left iliac vein and covered by the pelvic viscera. The vessel supplies the coccygeal body and the periosteum of the sacrum. According to Quain, several small twigs enter the anterior sacral foramen.

Virchow[1] has invited attention to the connection between the anomalies of the aorta and its branches, in heart disease—especially in endocarditis of the puerperal state—and imperfect development of the organs of generation. In cases of undue narrowing of the aorta throughout its thoracic and abdominal portions (aortic hypoplasia), associated with irregularity of origin of the intercostal, lumbar, and mesenteric branches, the genital organs retain in the adult of both sexes the appearances of youth, and the secondary characters of puberty are absent or imperfectly developed. With these structural peculiarities, chlorosis and a disposition to dilatation of the heart and endocarditis exist. The tunica intima of the aorta may be diseased. Virchow would thus define chlorosis to be a systemic disease of congenital origin, occurring in both sexes, and based upon defective blood-supply from a preternaturally contracted or imperfectly developed aorta.

In subjects in which the abdominal and genital organs are known to be imperfectly developed, careful study of the size of the thoracic and abdominal portions of the aorta, and of the arrangement of the branches, should be made.

THE COMMON ILIAC ARTERY.

The Common Iliac Artery extends from the termination of the abdominal aorta downward and outward to a point directly above and in front of the sacro-iliac junction, where it divides into the external and the internal iliac artery. The vessel measures two inches in length.

Relations.—The artery lies upon the lumbar vertebræ, along the median border of the Psoas Magnus muscle, and is covered by the peritoneum and intestine. The ureter crosses the artery at its origin. The relations existing between the two common iliac arteries and the corresponding veins differ. On the *left side* the artery lies to the lateral side of the common iliac vein. In front of it lie the sigmoid flexure and the lower part of the inferior mesenteric artery. On the *right side* the vein lies in the main behind the artery. Near its origin the artery lies to the inner side of the vein, then in front of it, and finally to the outer side. Behind it lie the sympathetic and the obturator nerves.

According to Holden, the direction of the vessel answers to that of a line drawn from the umbilicus downward and outward to the middle of the groin. The vessel can be felt rather nearer the pubes than the ilium. The upper part of this line answers to the common iliac, the lower part to the external iliac vessel.

The Ligation of the Common Iliac requires an incision similar to that for the external and internal iliacs (q. v.). An incision five inches in length may be made extending from just above the external abdominal ring, outward in a semicircular direction, one-half inch above Poupart's ligament, until it terminates a little beyond the anterior superior spinous process of the ilium. After division of the External Oblique muscle, the spermatic cord is used as a guide to the retro-peritoneal space. The circumflex iliac artery usually requires ligation. Or, an incision may be made two inches and three-quarters above the umbilicus, three inches from the median line, and passed thence six inches downward in a curvilinear direction. The line of the sacro-iliac junction is a guide to the artery.

The *collateral circulation* after this ligation is expressed by the following formulæ:—

Hæmorrhoidal branch of the Internal Iliac + Superior Hæmorrhoidal branch of the Inferior Mesenteric.

Uterine + Ovarian arteries.

Vesical of one side + Vesical of the opposite side.

Lateral Sacral + Middle Sacral.

Deep Epigastric + Internal Mammary.

Inferior Intercostal + Lumbar.

Ilio-Lumbar + Last Lumbar.

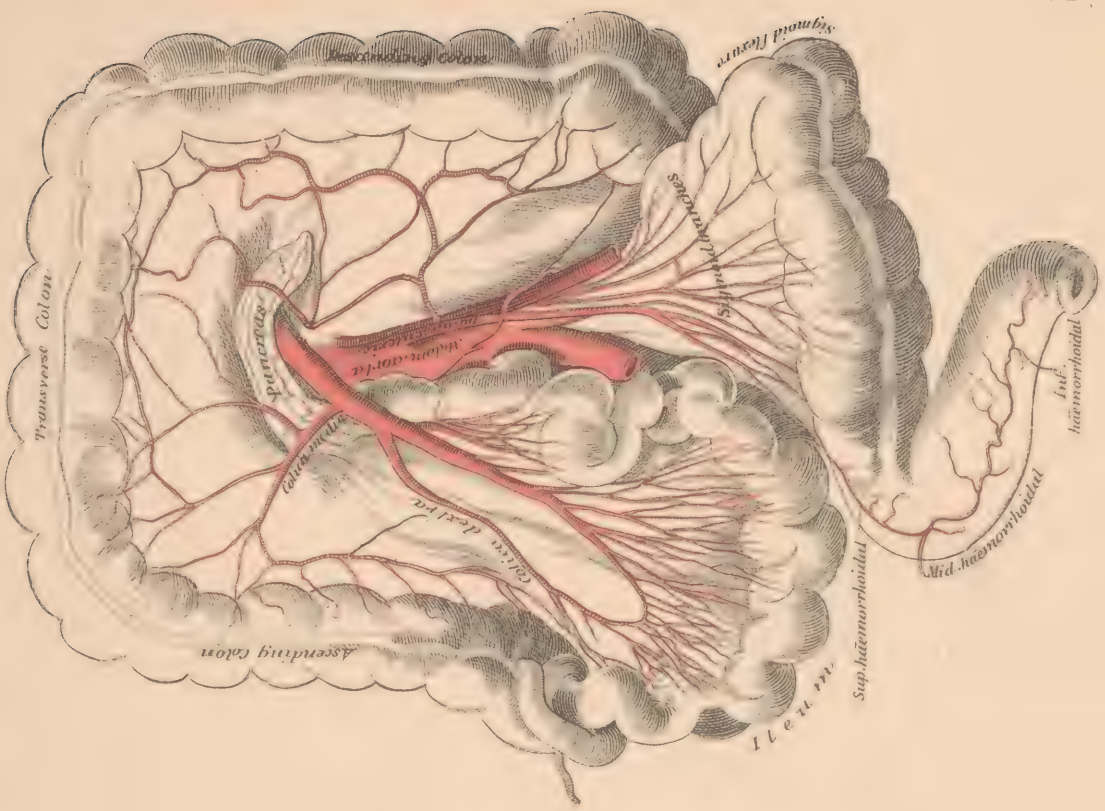
In a specimen showing such collateral circulation, preserved in the Wistar and Horner Museum, at the Uni-

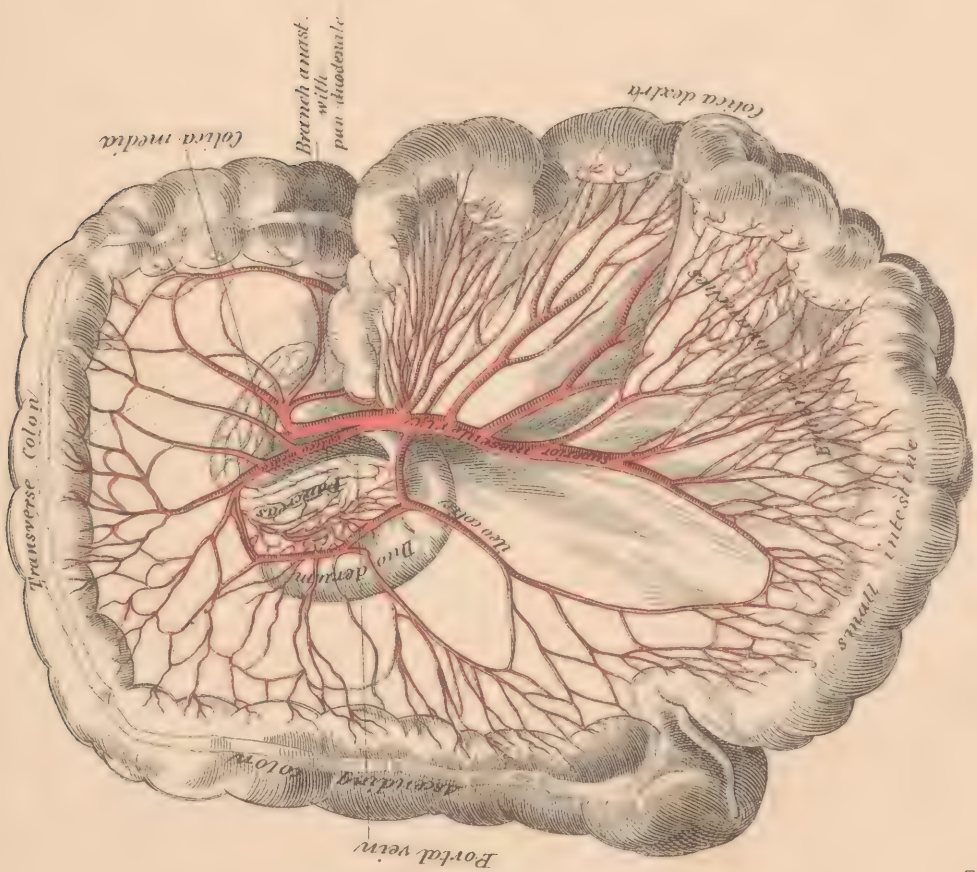
[1] Ueber die Chlorose und die damit zusammenhängenden Anomalien im Gefässapparate, etc. Literature and figures. Berlin, 1872.

EXPLANATION OF PLATE LXIX.

Fig. 1. The arterial supply of the intestines, showing especially the superior mesenteric artery and its branches.

Fig. 2. The arterial supply of the intestines, showing especially the inferior mesenteric artery and its branches.





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versity of Pennsylvania, the following junctions are conspicuous:—

Ilio-lumbar + Lumbar.
Obturator + Lumbar.
Obturator and Profunda Femoris + Ilio-Lumbar.

Cases of symmetrical gangrene of the lower extremities have been recorded in which the lumina of the common iliac arteries were obliterated by clots.[1]

THE INTERNAL ILIAC ARTERY.

The Internal Iliac Artery extends from the lateral aspect of the promontory of the sacrum toward the great sacro-ischiatic foramen. It is smaller than the external, measuring from one-and-a-half to two inches in length, and supplies the pelvic viscera, the external genitals in part, the anal walls, the buttock, and the origins of some of the muscles of the thigh.

In the fœtus the internal iliac gives off the *hypogastric* artery, which passes forward to the sides of the bladder, and thence ascends to the umbilicus. At this time the artery is larger than the external iliac. Some authorities have reserved to the internal iliac artery the name of hypogastric, even after the placental formations have disappeared, and the remains of the hypogastric artery have assumed a ligamentous form. It will be remembered that the vessel may be, though rarely, the seat of diseased action even in the adult. M. Fere records a case of aneurism of this vessel involving other branches of the internal iliac, and refers to two specimens. The tumors do not appear to induce special symptoms; at least it is noteworthy that in each instance recorded the specimen was secured in an autopsy where other causes for death were assigned, and where no histories of symptoms referable to the aneurism existed.

Relations.—The internal iliac artery is slightly curved, the concavity looking forward. Above it lies near the inner border of the Psoas Magnus muscle, and lower down it rests upon the Pyriformis muscle. Behind it lies the internal iliac vein. In front is the peritoneum with the ureter.

The pulsations of the iliac artery can, under favorable circumstances, be felt by rectal palpation.

Ligation of the Internal Iliac Artery.—Holden thus describes the method of ascertaining the position of the internal iliac: Draw a line from the outer side of the tuberosity of the ischium to the posterior superior spine of the ilium. The junction of the lower with the middle third of this line gives the position of the artery.

The operation is essentially the same as that for the external iliac. It may be necessary slightly to enlarge the primary incision, in order to obtain room enough for the manipulations requisite in reaching the deeper-seated internal iliac. In view of this fact, the incision in the skin may be five inches long. The line of the first incision should extend from the umbilicus to a point midway between the spine of the pubis and the anterior superior spinous process of the ilium; this incision should begin at the outer edge of the Rectus muscle, and terminate about an inch above Poupart's ligament in order to avoid the spermatic cord. The remaining steps of the operation are the same as those for ligation of the external iliac. The vein lies behind and toward the outer side of the vessel on the right side, or in the angle between the internal and external iliac arteries. The ureter need not interfere, since it is raised and pushed away with the peritoneum.

The internal iliac artery divides into two branches, an anterior and a posterior. The branches of these in turn may be arranged as follows:—

Anterior Branch.
- (*a*) Vesical.
- (*b*) Obturator.
- (*c*) Internal pudic.
- (*d*) Uterine.
- (*e*) Vaginal.

Posterior Branch.
- (*f*) Sciatic.
- (*g*) Gluteal (superior).
- (*h*) Ilio-lumbar.
- (*i*) Lateral sacral.

Luschka adds to the anterior branches an inferior gluteal. The hypogastric artery of the fœtus arises from the anterior branch. Henle includes the arteries supplying the pelvic viscera as median branches. The obturator artery sometimes arises from the posterior branch.

(*a*) The *vesical* arteries are two in number, the superior and the inferior.

The *superior vesical* artery supplies the posterior wall and sides of the bladder. It is continuous with the remains of the hypogastric artery of the fœtus.

The *inferior vesical* artery accompanies the ureter to the base of the bladder, vesiculæ seminales, and vas deferens. It also supplies the prostate gland, and, in females, the lower part of the vagina. It anastomoses with the spermatic artery.

Variations.—The artery is often duplicated or is even multiple.

(*b*) The *obturator* artery passes forward along the lateral wall of, and a short distance below, the brim of the true pelvis, between the nerve and vein of the same name. It lies between the obturator fascia and the peritoneum, and enters a special passage (obturator canal) at the superior border of the obturator foramen by which it obliquely pierces the obturator membrane, and divides into its terminal branches, the internal and external obturator arteries. The *internal*

[1] Dupuy, Bull. de la Soc. Anatomique, t. xlvii. 1872, 285.

obturator passes around the inner margin of the foramen, and, lying between the Adductor Longus and Adductor Brevis, and supplying these muscles, together with the Gracilis and Pectineus, anastomoses with the internal circumflex femoral. The *external* passes round the outer margin of the foramen, and supplies the Quadratus Femoris and Obturator Externus muscles, and the origins of the flexors. It anastomoses with the external circumflex femoral and with the internal branch. The artery sends in addition a small branch to the hip-joint through the cotyloid notch, supplying the lining membrane of the acetabulum, the round ligament, and the head of the femur. While within the pelvis the obturator artery yields small twigs for the Internal Iliac, Psoas, Levator Ani, and the Obturator Internus muscles, and, just before entering the obturator canal, sends a small pubic branch to the connective tissue behind the symphysis pubis. These branches anastomose with corresponding twigs of the opposite side, and often with the deep epigastric artery of their own side.

Variations.—The obturator artery may arise from the posterior branch of the internal iliac. Some writers describe this as the normal arrangement. Its terminal portion may take the place of the internal pudic, and supply the artery of the bulb or the dorsal artery of the penis, as well as the strictly pelvic branches, such as the vesical and the uterine. It is interesting, on the other hand, to remark its close relation to the external iliac artery and its branches —a class of variations more common in the female than the male. It rarely arises from the main trunk, but frequently (in about one-fourth of the subjects) it arises in common with the deep epigastric. It may even arise, although very rarely, from the external iliac at Poupart's ligament. In the latter instance, as well as in some instances of its origin from a common trunk with the deep epigastric, the obturator artery passes over the femoral vein, curves round to the inner side of the femoral canal, and would in this position of course be wounded in operating for femoral hernia. Fortunately this variety is so rare that practically it does not often enter into the surgeon's calculations of the risks attending this operation. In a patient of Dupuytren's, aged 60, operated upon for femoral hernia, after the urgent symptoms had ceased severe diarrhœa set in and death ensued. On dissection, a broad layer of effused blood was observed through the peritoneum, evidently placed between that membrane and the transversalis fascia, extending from the lower part of the pelvis nearly to the umbilicus. The hemorrhage had taken place from the obturator artery, which in this case had arisen from the external iliac by a trunk common to it and the epigastric, and had nearly surrounded the neck of the sac, and which during the operation had been cut across.[1]

[1] John Reid, Edin. Med. and Surg. Journal, 1836, xlvi. 66.

The fact that the origin of the obturator artery from the epigastric is more common in the female than in the male is worthy of more than a passing notice, in view of the fact that femoral hernia is almost peculiar to the female. When the artery thus arises, it proceeds downward and inward, first passing along the outer side of the femoral canal, and then along its posterior margin to reach the upper portion of the obturator foramen.

(*c*) The *internal pudic* artery. This vessel is slightly larger than the obturator. It arises from the lower part of the anterior division, passes across the cavity of the pelvis between the rectum and the outer wall, and escapes at the lower part of the great sciatic foramen in company with the sciatic nerve. It thence turns round the spine of the ischium, enters the pelvis through the lesser sciatic foramen, is received within a groove defined by the falciform process of the great sacro-sciatic ligament and the bone, and passes thence upward and forward within the obturator fascia about one-and-a-half inch above the tuberosity to the subpubic arch, where it terminates between the layers of the deep perineal fascia in the *deep artery of the penis* and the *dorsal artery of the penis*.

The internal pudic artery thus describes an irregular course which consists of four stages. The *first*, from its origin to the great sciatic foramen; the *second*, as it winds round the spine of the ischium; the *third*, as it lies within the obturator fascia; and the *fourth*, as it lies between the layers of the deep perineal fascia.

In the first stage it lies at first external to the sciatic nerve, and afterwards in front of it. Below, it lies at the lower border of the Pyriformis muscle. It is here accompanied by the pudic nerve and vein.—In the second stage the artery and its accompanying nerve and vein are covered by the Gluteus Maximus muscle.

It is concealed from view in operations upon the perineum. W. L. Atlee[1] mentions a case of rupture of a branch of this artery during childbirth, resulting in a large hæmatoma of the internal genitals.

In the *first* stage the internal pudic gives origin to the *middle hæmorrhoidal artery*. It supplies the base of the bladder, the prostate gland, and the portion of the rectum not covered by peritoneum. It anastomoses with the superior and inferior hæmorrhoidal.—In the *second*, it gives off several small branches which supply the Gluteus Maximus, Pyriformis, and Obturator muscles.

[1] Ovarian Tumors, 364.

In the *third* stage the branches of the internal pudic are—

(1) Inferior Hæmorrhoidal.
(2) Superficial Perineal.
(3) Transverse Perineal.

(1) The *inferior hæmorrhoidal* artery pierces the obturator fascia, and is directed across the fat of the ischio-rectal fossa to the lower part of the rectum. It supplies the Levator Ani and the skin about the anus. The vessel may be divided in lithotomy by a too free prolongation backward of the first incision. The artery is often duplicated.

(2) The *superficial perineal* artery pierces the obturator fascia, and is directed forward toward the urogenital portion of the perineum. It becomes superficial at the Transverse Perineal muscle, which it crosses to be received between the Ischio-Cavernosus and Bulbo-Cavernosus muscles. It supplies these muscles, and is finally lost on the posterior aspect of the scrotum.

(3) The *transverse perineal* artery is a small vessel which pierces the obturator fascia, and passes directly inward along the posterior border of the muscle of the same name. It is necessarily divided in lithotomy.

In the *fourth* stage the branches are—

(1) Artery of the bulb.
(2) Deep artery of the penis.
(3) Dorsal artery of the penis.

(1) The *artery of the bulb* is a short but relatively stout branch, which enters between the two layers of the deep perineal fascia, near their posterior border, and is received within the bulb of the urethra. It sends a branch to Cowper's gland.

(2) The *deep artery of the penis*. This passes between the Ischio-Cavernosus and the Bulbo-Cavernosus muscles, to enter the cavernous body to its inner side.

(3) The *dorsal artery of the penis* pierces the subpubic fascia and the suspensory ligament of the penis, and passes along the dorsal groove of the penis, in company with the artery of the opposite side. It anastomoses at the glans penis with its fellow, and with the preceding vessel. It supplies the fibrous investment of the cavernous body, the skin, and the glans penis. Hyrtl has seen it arise from the external pudic.

Variations.—The internal pudic artery may not have an independent origin from the internal iliac, but may arise from a trunk in common with the obturator. The artery may be entirely pelvic, when it will send branches to the urogenital portion of the perineum. The dorsal artery of the penis in this event will reach its destination by passing forward over the prostate body. The artery may remain pelvic, as far as the main distribution of the vessel is concerned, but may send the superficial perineal outward. This branch escapes through the great sciatic foramen as the main vessel normally does, but passes forward to supply the urogenital region from the cutaneous aspect. It is apt to run midway between the anus and the tuberosity of the ischium, and is in danger of being divided in the lateral operation of lithotomy.—The artery may be almost entirely external, when it terminates in the bulbous portion of the spongy body.—In rare examples the vessel may be for the most part directed toward the posterior aspect of the thigh. In the two preceding variations, the perineal branches are commonly supplied by a branch separate from the internal pudic at the third stage, called by Quain the accessory pudic.

The dorsal artery, the artery of the bulb, and the pelvic branches may come severally from the obturator artery. The vessels last named may, in rare instances, come from the femoral.

In the female the internal pudic is so far modified as to yield the superficial perineal to the labia majora, the artery of the bulb to the labia minora, and the dorsal artery of the penis to the clitoris. The latter vessel also supplies the lower part of the vagina.

(*d*) The *uterine* arteries are exceedingly tortuous. They are received between the folds of the broad ligament, and yield an ovarian branch, a branch to the Fallopian tube, and a third to the round ligament. These branches are exceeding tortuous, and anastomose with the ovarian artery of the abdominal aorta, which thus is less intimately associated with the ovary than the spermatic artery is with the testis. During pregnancy, and probably in morbid conditions, the distribution of the ovarian artery is enormously increased at the body and the fundus, while the uterine branch of the internal iliac is retained chiefly at the neck of the uterus.

(*e*) The *vaginal* artery represents the inferior vesical in the male. It sends a few twigs to the bladder and to the rectum.

(*f*) The *sciatic* artery is situated in front of the Pyriformis muscle and the sacral plexus. After sending some branches to the fat of the ischio-rectal fossa, it escapes at the lower border of the great sciatic foramen, and supplies the outward rotators of the thigh and the Gluteus Maximus; it also sends a small artery (*comes nervi ischiadici*) along the sciatic nerve. The coccygeal artery is the name given to a small branch which pierces the great sacro-sciatic ligament, and is distributed to the parts behind the coccyx.

(*g*) The *gluteal* artery is the largest branch of the internal iliac. It passes backward, outward, and downward over the Pyriformis to the upper

border of the great sciatic foramen. It divides into two branches, the *deep* and the *superficial*. The deep lies between the Gluteus Maximus and the Gluteus Medius; the superficial between the Gluteus Medius and the Gluteus Minimus. This artery gives off a nutrient branch to the ilium.

Holden[1] gives the following direction for finding the gluteal artery: Rotate the femur inward, and draw a line from the posterior superior spinous process of the ilium to the trochanter minor. The junction of the upper with the middle third of this line lies over the artery as it emerges from the upper border of the great ischiatic notch.

(*h*) The *ilio-lumbar* artery. This artery passes outward and upward behind the Psoas Magnus muscle. It divides into two branches, an upper, which ascends to supply the Psoas Magnus and the Quadratus Lumborum, and a descending, which supplies the Iliacus Internus. This branch anastomoses with the circumflex ilii, and the lumbar branch with the last lumbar and the lowest intercostal arteries. A nutrient artery for the ilium may arise from this vessel. Another branch enters the spinal cord between the last lumbar vertebra and the first sacral to supply the *cauda equina*.

(*i*) The *lateral sacral*. This vessel gives off an upper and a lower branch, both of which are distributed to the sides of the sacrum. They anastomose with the median sacral. The outer branches of the artery enter the sacral foramina, and are lost upon the membranes of the spinal cord. Its lower twigs anastomose with the coccygeal branch of the *sciatic*.

Hemorrhage from a wounded branch of the internal pudic can be checked (should the bleeding occur in advance of the great sciatic ligament) by pressure beneath the spine of the ischium. Harrison[2] mentions an instance of such pressure being successfully employed by the patient himself.

THE EXTERNAL ILIAC ARTERY.

The External Iliac Artery begins at the lateral border of the fifth lumbar vertebra, or at the sacro-iliac junction, and terminates at Poupart's ligament, where it is continuous with the femoral. Its direction is downward and slightly outward between the Psoas muscle and the brim of the true pelvis. It measures from three-and-a-half to four inches in length.

Relations.—Behind the artery lies the vein of the same name. It gradually secures a position to the inner side, and at Poupart's ligament it is entirely to this side. Both the artery and the vein are surrounded by subperitoneal connective tissue. In front of the artery lies the peritoneum. For the upper four-fifths of the artery, this membrane is in contact with the artery; but for the lower fifth, the membrane, as it passes from the abdominal wall to the iliac fossa, does not touch the vessel, which is here surrounded by fat and lymphatic glands.[1]

Remarks.—R. J. Levis[2] reports a case of fatal hemorrhage from the left external iliac artery following a perforating ulcer, the result of the pressure from a symmetrical chronic psoas abscess that had opened externally. The blood escaping from the opened vessel filled the cavity of the abscess before escaping from the external orifice.

The branches of the external iliac artery are—

(*a*) The deep epigastric.
(*b*) The circumflex ilii.

(*a*) The *deep epigastric* arises from the inner aspect of the artery. It passes downward and slightly inward as far as the inguinal canal. It here describes a curve whose concavity is upward, and is crossed by the vas deferens. It thence ascends obliquely to reach the anterior abdominal wall, and passes upward to the outer border of the sheath of the Rectus, which it pierces, and lies upon the muscle posteriorly as far as the umbilicus, where it anastomoses with the internal mammary and the lower intercostal arteries.

Variations.—The most important variation is the origin of the obturator artery from the epigastric (see the description of that vessel). An aberrant branch ascending the anterior abdominal wall has been wounded, according to Berard, in the performance of paracentesis. The vessel occasionally rises higher than usual, or it may take its origin from the femoral.

The branches of the deep epigastric are—

(1) Cremasteric.
(2) Pubic.
(3) Muscular.

(1) The *cremasteric*, entering the inguinal canal, supplies the Cremaster muscle, and the coverings of the spermatic cord. In the female the cremasteric artery supplies the fat of the mons veneris, the labia, and the round ligament.

(2) The *pubic*, ordinarily a small branch, is directed to the connective tissue behind the pubis, where it anastomoses with the artery of the opposite side and with the obturator.

(3) The *muscular* branches supply the Rectus muscle and the skin of the abdomen.

The deep epigastric artery is accompanied by two

[1] Landmarks, 88. [2] Surg. Anat. of Arteries, 322.

[1] Lewinsky, Œster. Zeitschrift für prakt. Heilkunde, Wien, 1863.
[2] Phila. Med. Times, xi. 1881, 380.

veins, one on either side. These unite inferiorly in the single trunk lying to the inner side of the artery.

(*b*) The *circumflex ilii* artery arises from the outer side of the external iliac. It passes outward between the transversalis fascia and the peritoneum, above Poupart's ligament, to the crest of the ilium, along which it proceeds to about its middle, where it pierces the Transversalis; for the rest of its course it lies between this muscle and the Internal Oblique. Its terminal branches anastomose with the lumbar and epigastric arteries. The artery may arise a little higher than usual, or it may come off from the femoral.

Ligation of the External Iliac Artery.—An incision is made one-half an inch above Poupart's ligament, extending from above the anterior superior spinous process to a little above the inner margin of the external abdominal ring. The incision should be curved downward toward Poupart's ligament. The abdominal muscles are successively divided until the transversalis fascia is reached. The space between this fascia and the peritoneum is opened near the outer end of the wound, and the finger, reaching the iliac fossa, is guided by it to the position of the artery. The anterior crural nerve lies to the outer side of the artery, and the vein to the inner side.

In Sir Astley Cooper's operation, the incision through the External Oblique muscle apparently opened the inguinal canal, and the deep epigastric artery was used as a guide to the position of the external iliac. The position of the deep epigastric is not to be forgotten in the latter procedure. Dupuytren lost a patient by wounding it; as did Béclard by tying the iliac immediately beneath its origin, so that insufficient space was left for the formation of a coagulum.[1]

In a dissection made ten weeks after the ligation of the external iliac artery, Astley Cooper[2] met with the following arrangement of the *collateral circulation*:—

Internal Iliac	External Pudendal.
Lateral Sacral	Epigastric.
	Branch of Femoral.
	Obturator.
Ilio-Lumbar	Circumflex Ilii.
Branch of Internal Iliac	Profunda Femoris.
Gluteal	External Circumflex.

In a second specimen described by the same authority, the following was noticed:—

Branch of Internal Iliac	Epigastric.
	Obturator.
Same	Internal Circumflex.
Gluteal	Profunda Femoris.
Internal Pudic	Obturator.

[1] Power's Anat. of the Arteries, 1862, 325.

[2] Med.-Chir. Trans., iv. 1813, 428, fig.

THE FEMORAL ARTERY.

The Femoral Artery is the continuation of the external iliac artery. It pursues a straight course from above downward, starting at Poupart's ligament at a point midway between the anterior superior spinous process of the ilium and the spine of the pubis, and terminating at the beginning of the lower third of the thigh at the annular opening of the Adductor Magnus. It passes nearly vertically downward, lying upon the Adductor Longus and Adductor Magnus muscles. In consequence of the oblique position of the shaft of the femur, the artery lies in front or to the inner side of the bone at the groin, but close to the inner side of the shaft below. The course of the artery is nearly parallel to a line drawn from the centre of Poupart's ligament to the inner margin of the patella.

The artery can be felt about an inch below the spine of the pubis.

Ligation of the Femoral Artery.—Ligation above the origin of the profunda. The limb being flexed and abducted, an incision two inches and a half in length is made, beginning at the lower border of Poupart's ligament, and extending in a line drawn from the middle of the ligament downward and inward to the inner femoral condyle. The skin being divided, the lymphatic glands and superficial veins are carefully avoided, the sartorial fascia opened, and the inner edge of the Sartorius muscle drawn outward. The sheath of the vessels is now carefully opened, and the needle passed from without inward to avoid the vein which lies to the outer side of the artery. Troublesome bleeding may arise from neglecting some of the small arteries supplying the sheath.

Porter, of Dublin, has recommended a transverse incision. This method might present advantages over the longitudinal in an attempt to secure the artery in the stump of an amputation of the thigh high up. Ligation below the profunda includes two procedures—one in Scarpa's triangle, and one in Hunter's canal.

The ligation in Scarpa's triangle is performed by making a longitudinal incision three inches in length in the line above mentioned, and beginning three inches below Poupart's ligament. Using the inner edge of the Sartorius muscle as a guide, the sheath of the vessels is readily found lying beneath its inner border. The sheath is opened to a small extent, and the needle passed from within outward with great care, since the vein lies beneath the artery. Power recommends that a small blunt instrument, such as an eye-probe, should be used in separating the artery and the vein before introducing the needle. Small branches of the crural nerve usually lie to the outer side of the sheath.

French authors recommend drawing the Sartorius muscle inward in searching for the artery.

Ligation in Hunter's canal. This operation is rarely resorted to. It is performed by making an incision from the apex of Scarpa's triangle, downward for a distance of three-and-a-half inches. The internal saphenous vein and the long saphenous nerve are carefully avoided, the deep fascia over the Sartorius muscle divided, and the muscle drawn downward. The anterior wall of the canal is now exposed. This being carefully opened, the artery is exposed. Great care should be taken not to mistake an enlarged anastomotica magna for the main vessel.

The *collateral circulation* after ligature of the femoral artery above the profunda femoris artery:—

- Gluteal Circumflex Iliac + External Circumflex.
- Obturator Sciatic + Internal Circumflex.
- Ilio-lumbar + External Circumflex.
- Comes Nervi Ischiadici + Arteries in Popliteal Space.

Below the profunda femoris artery:—

- Branches of the Profunda Femoris
  - Internal Circumflex + Superior Articular. Recurrent branches of Tibial. Anastomotica Magna.
  - External Circumflex + Recurrent branch of Anterior Tibial. Gastrocnemial branch of Popliteal. External Articular.
  - Terminal Branches + Superior Articular Arteries.
- Comes Nervi Ischiadica + Muscular branches of Popliteal. Branches of Posterior Tibial.

After ligation of the femoral above the origin of the profunda femoris for a popliteal aneurism, Sir A. Cooper[1] found the collateral circulation to be established in the following manner: The profunda was enlarged. Several of its branches passed along the course of the sciatic nerve, anastomosing with the inferior articular artery of the popliteal. Another branch anastomosed with the two superior articular branches of the popliteal. Another passed along the inner side of the Biceps muscle, to anastomose with a branch of the popliteal, supplying the Gastrocnemius muscle. The external circumflex artery was larger than usual, but effected no anastomosis. The obturator was not changed.

In a specimen in which the circulation had been established after a similar operation, John D. Hill[2] found the anastomotica magna inosculating with the superior articular, and thence joining the anterior tibial recurrent artery on the inner side. The descending branch of the external circumflex artery received the superior articular, and anastomosed with a branch of the anterior tibial recurrent. Then the latter artery represented a stem into which the blood from both the anastomotica and the external circumflex flowed. This in its turn was continuous with the anterior tibial, the posterior tibial being joined to the latter vessel by a few intermediate vessels.

The femoral artery may divide into two branches just below the origin of the profunda. These branches may remain distinct afterward, or may re-unite at the tendinous orifice in the Adductor Magnus muscle to form the popliteal. Sir Chas. Bell described[1] an anomaly of this description which was associated with popliteal aneurism. The recorder had tied one of the two femorals for the cure of the disease. The anomaly was not detected until the parts were dissected after death.

Mr. Houston[2] states that, in an example of a similar anomaly which had come under his notice, the internal vessel supplied the Adductor muscles, while the external supplied the Vastus Internus, and gave origin to the anastomotica magna.

Remarks.—The artery bears a more intimate relation to the femur than the brachial bears to the humerus. Instances of lesion, or of morbid action in the vessel, following injury or disease of the bone, are frequent. The vessel is more apt to be affected at its point of passage through the Adductor Magnus than elsewhere. In a case of varicose aneurism described by J. G. Perry,[3] in a male aged forty-seven years, a communication between the femoral artery and vein occurred at the above locality. After death the external iliac was found to be very tortuous, and the femoral greatly dilated and attenuated, while an aneurismal distension was situated upon the popliteal artery. The inextensile opening in the Adductor Magnus in this instance resisted the tendency of the vessel to dilate at this point, and determined the communication with the femoral vein.

H. Thompson[4] records a case of fatal hemorrhage in a boy aged nine years, from a superficial aberrant femoral artery, which wound round the shaft of the femur directly above the internal condyle. The vessel had been ruptured by a spicule of the necrosed shaft of the bone. In a case of spontaneous rupture of the femoral artery, occurring in a gouty subject, a male of seventy-three years, Leggett[5] found the Sartorius, Rectus Femoris, Vastus Internus, and Adductor muscles more or less infiltrated by extravasated blood. The femoral vessels were pushed inward, while the blood had passed upward along the crural canal, and had to some extent infiltrated the Psoas and Iliacus muscles.

Th. Z. Kneider[6] has described a case of a small pulsating tumor arising over the left portion of the pubis, consequent upon a violent blow received at that point, in a man aged forty-eight. On the seventh day after the injury, the collection emptied into the scrotal tissues. The recorder

[1] Med.-Chir. Trans., ii. 1809, 249, figs.
[2] Lancet, 1869, ii. 297, fig.

[1] Anderson's Quarterly Journal, Oct. 1826.
[2] Dublin Hospital Reports, 1827, 313.
[3] Med.-Chir. Trans., xx. 1837, 31.
[4] Dublin Journ. of Med. Sci., iv. 1847, 251.
[5] Trans. Path. Soc. Lond., ix. 1858, 163.
[6] Ohio Med. and Surg. Journ., i. 1848, 120.

opened the scrotum, cleared out the clot, and tied a branch of the superficial epigastric artery. The patient recovered.

The branches of the femoral artery are—

(*a*) Superficial Epigastric.
(*b*) Circumflex Iliac.
(*c*) External Pudic.
(*d*) Muscular Branches.
(*e*) Profunda Femoris.
(*f*) Anastomotica Magna.

(*a*) The *superficial epigastric* artery is small, but constant. It arises from the front of the trunk, from half an inch to an inch below Poupart's ligament. It gives small branches to the inguinal glands, and passes directly upward, piercing the fascia lata, and ascending the abdominal walls in the superficial fascia as far as the umbilicus, where it divides into two branches, an internal and an external, both of which join branches of the internal mammary and deep epigastric arteries.

(*b*) The *circumflex iliac*, the smallest of the branches, arises from the outer part of the main trunk, passes outward and slightly upward across the Psoas and Iliacus muscles, to which it gives branches parallel to Poupart's ligament throughout its entire length. At the anterior superior spinous process it pierces the fascia lata, and divides into two branches.

(*c*) The *external pudic* arteries are two in number, a superficial and a deep. They arise from the upper and inner part of the main trunk, and, as the name expresses, supply the parts about the superficies of the external organs of generation.

The *superficial* extends through the coarse cellular adipose tissue of the groin, obliquely upward and inward, crosses the external abdominal ring, and gives branches to the lymphatic glands, and reaching the pubis (in the male it crosses the spermatic cord) it sends a branch to the skin of the penis and scrotum of the male, and to the labium major of the female. The *deep* branch takes its origin a short distance below the superficial beneath the femoral aponeurosis. It lies between this structure and the Pectineus muscle, and crosses the femoral vein on its way inward to pierce the fascia lata on the inner side of the thigh, in front of the Adductor Longus muscle. It crosses the spermatic cord and supplies the scrotum in the male and the labium major in the female, and sends downward a perineal branch. The artery anastomoses with the obturator artery, with the superficial perineal of the internal pudic, and with the artery of the same name of the opposite side. It is sometimes a branch of the profunda.

(*d*) The *muscular branches* are small and inconstant; they supply the muscles about the femoral artery, particularly the Sartorius and Vastus Internus.

(*e*) The *profunda femoris* (deep femoral artery), the largest branch of the femoral, is often of equal calibre with it. It is the main nutrient artery of the thigh, since the femoral is in the main an artery of transit to supply the leg and foot. The deep femoral artery arises from the outer side of, or directly behind, the femoral, halfway between the pubis and the lesser trochanter, about one-and-a-half to two inches below Poupart's ligament. At first the vessel is curved slightly outward in front of the Iliacus, thence passes over the Vastus Internus muscle and descends the limb, lying parallel with the femoral artery, but soon passes behind it and sinks between the Adductor Longus and Adductor Magnus muscles, and is lost in the muscles of the thigh.

A. H. Young[1] describes an instance of absence of the profunda. Its function was performed by branches arising from the femoral after it had pierced the Adductor Magnus.

The deep femoral yields the following branches:—

(1) The External Circumflex.
(2) The Internal Circumflex.
(3) The Perforating.

(1) The *external circumflex* artery arises from the outer side of the curved portion of the femoral vessel, passes outward between the divisions of the anterior crural nerve in front of the Psoas muscle, to which it gives a small branch, thence between the Vastus Internus and Rectus muscles, and divides into three sets of branches, ascending, transverse, and descending.

The *ascending* passes through the interval between the Iliacus and Gluteus Medius muscles to supply the Tensor Vaginæ Femoris, Gluteus Medius, and Gluteus Minimus. It communicates with the circumflex iliac artery. The *transverse* passes outward over the Crureus, pierces the Vastus Externus, and, winding around the great trochanter, pierces the insertion of the Gluteus Maximus, to anastomose with the internal circumflex and the superior perforating arteries, as well as with gluteal and sciatic branches of the internal iliac. It gives a branch to the capsule of the hip-joint. The *descending*, the largest of the three branches, supplies the Quadriceps extensor muscle. It is directed downward between the Rectus and Crureus, and between the Vastus Externus and Crureus it divides into several branches which supply the Quadriceps muscle as far as the lower part of the

[1] Journ. Anat. and Phys., xiii. 1879, 154.

thigh, and unites with branches which supply the joint. This branch is often greatly enlarged in cases of popliteal aneurism, and in amputations of the thigh it often requires a ligature.

(2) The *internal circumflex*, larger than the external, arises from the inner side of the main trunk. It soon passes to the inner side of the tendon of the Psoas muscle, and winds between the Pectineus and the head of the femur to gain the space in front of the Obturator Externus muscle, where it divides into two branches, an ascending and a transverse branch.

The *ascending branch.* Opposite the Obturator Internus it sends a branch upward which supplies that muscle, the Gracilis and the upper portion of the adductors. It anastomoses with the Obturator Internus. A twig ascends in front of the Quadratus Femoris muscle to reach the digital fossa, and sends branches to neighboring muscles. It anastomoses with the sciatic, gluteal, and external circumflex arteries.

The *articular.* This is often a separate vessel, but may be a branch of the foregoing. It enters the hip-joint through the cotyloid foramen, and supplies the cushion of fat and the ligamentum teres. A twig from the obturator artery frequently takes the place of this branch, or the vessel may be the result of the union of twigs from both. The capsular branches joining the articular in addition supply the periosteum of the neck of the femur, and, according to Sappey, extend along the synovial membrane to the head of the femur.

The *transverse* branch pierces the adductor group at the space between the Adductor Magnus and Quadratus Femoris muscles, to gain the posterior aspect of the thigh, where its lower branches supply the upper portion of the Quadriceps, the Semi-Tendinosus, the Semi-Membranosus, and the lower part of the Gluteus Maximus, as well as the sciatic nerve. The periosteum of the great trochanter and the posterior surface of the neck of the femur also receive twigs from the same vessel.

The vessel has a general course which recalls that of the posterior circumflex artery of the superior extremity. Cruveilhier asserts that it has been ruptured in upward dislocations of the hip.

In intra-capsular fracture it is from the vessels which supply the synovial membrane of the hip-joint that the detached head derives its nourishment.

The vessel freely anastomoses with the terminal branches of the gluteal, the sciatic, and the pudic, and with the transverse branches of the external circumflex and superior perforating arteries. These facts are of importance to remember in connection with establishing a collateral circulation after ligation of the internal iliac or femoral arteries above the origin of the profunda femoris.

(3) The *perforating* arteries are usually three in number. Each pierces the Adductor Magnus muscle near its tendinous attachment. These arteries supply the adductor and the posterior flexor muscles, and anastomose one with another. The second is remarkable for furnishing the *nutrient artery* of the femur. The fourth supplies the short head of the Biceps and other hamstring muscles, and communicates with branches of the popliteal artery; it is sometimes called the terminal artery of the profunda.

(*f*) The *anastomotica magna* is a small branch which arises from the femoral just as that vessel pierces the Adductor Magnus to become popliteal. It is directed downward, resting upon the Adductor Magnus, and between it and the Vastus Internus, to the region of the internal condyle, where it divides into two branches, a superficial and a deep. The *superficial* passes along the tendinous cord of the Adductor Magnus in company with the long saphenous nerve, beneath the Sartorius, to the skin, and divides into two branches, one of which anastomoses in front of the patella with the superior articular artery; the other anastomoses with the articular branch of the recurrent tibial artery. The *deep* part of the vessel crosses the femur between the fibres of the Vastus Internus, gives branches to the knee-joint, and forms an arch above the articulating surface by union with the superior external articular artery.

Scarpa's triangle is a topographical region upon the anterior aspect of the thigh, and is of importance in connection with the position of the femoral artery. The base of the triangle corresponds to Poupart's ligament; the median side of the triangle is formed by the Adductor Longus; and the lateral side by the Sartorius. The floor of the space defined by the triangle is occupied by the conjoined tendon of the Psoas Magnus and the Iliacus Internus, the Adductor Brevis, the Adductor Magnus, on either side of the foregoing, and the Adductor Longus. The floor is crossed in the middle from end to end by the femoral artery, the femoral vein, and the anterior crural nerve and branches. The space is covered in by the fascia, the superficial and deep lymphatic glands of the thigh, and the skin.

The *relations* of the femoral artery are naturally embraced in part with those of Scarpa's triangle, and are shown in the following plan.

In the region lying between Poupart's ligament and

a line uniting the trochanter major to the symphysis pubis, the artery is superficial, and lies upon the median portion of the conjoined tendon of the Psoas Magnus and the Iliacus Internus. Laterally, lies the anterior crural nerve; medianly (and inclining to a plane deeper than that of the artery), lies the femoral vein. The artery is covered by the deep and superficial fascia and by some lymphatic glands.

In the region extending from the above line to the middle of the thigh, the artery lies upon a quantity of connective tissue and fat occupying the interval between the Vastus Internus on the lateral, and the Adductor Brevis and Adductor Magnus muscles on the median, side. Laterally, lie the long saphenous nerve and a second branch of the anterior crural nerve, the Sartorius muscles, and indirectly the Vastus Internus muscle and the shaft of the femur. The profunda femoris branch here lies parallel to the vessel.

In the region extending from the middle of the thigh to the lower fourth, the artery lies upon the glistening tendon of the Adductor Longus, and nearly parallel to the fibres of that muscle. At its termination, it lies upon the tendon of the Adductor Magnus. Laterally, lie the femoral vein, the Vastus Internus muscle, and indirectly the shaft of the femur; medianly, lie a quantity of connective tissue fat and the skin. The vessel is covered by a layer of fibres extending from the Vastus Internus to the Adductor Longus and the Adductor Magnus (the canal of Hunter), by the Sartorius muscle, and indirectly by fascia and skin.

Variations.—The femoral artery may be double. The second vessel then becomes one branch of an island-formation, of which the normal vessel is the other branch. As a rule, it is a branch of the external iliac artery, and joins either the femoral or the popliteal artery. A vessel—the long saphenous artery—may be seen accompanying the long saphenous vein. When this vessel arises above the point of origin of the profunda femoris, it supplies the thigh alone; but, when it arises below the point of origin of the profunda, it may pass to the leg and even reach the ankle. It is plain that the failure of an operation dependent on ligation of the femoral artery may be attributed, among other causes, to the presence of a second femoral or of an enlarged long saphenous artery.—A small artery may arise from the femoral, and pass upward over the antero-median portion of the thigh, where it may as a consequence be divided in femoral herniotomy.

The femoral artery may be small and supply only the upper and middle portions of the thigh. The ischiatic artery in such specimens is unusually large.

The profunda femoris may arise near Poupart's ligament. It often arises from the median side of the femoral or behind it, but rarely from the anterior surface. The profunda, when found lying to the median side of the femoral, will be found to give off the internal circumflex, and when lying to the lateral side, the external circumflex.[1]

THE POPLITEAL ARTERY.

The Popliteal Artery is the continuation of the femoral. It begins at the annular opening in the Adductor Magnus muscle, at the lower fourth of the posterior aspect of the thigh. It passes downward within the popliteal space, crosses the posterior surface of the capsular ligament of the knee-joint, and lies upon the Popliteus muscle, and at the upper border of the Soleus muscle, as it crosses the interosseous space, it terminates in the anterior and the posterior tibial arteries. It lies deep throughout, and is strictly popliteal in its relations, save where it passes *beneath* the Semimembranosus and the Gastrocnemius. It divides at a point one inch and a quarter below the head of the fibula, and one inch below the head of the tibia.

The branches of the popliteal artery are arranged as follows:—

(*a*) Muscular.
(*b*) Lateral Articular.
(*c*) Median Articular.

(*a*) *Muscular* branches are given off above the line of flexion of the knee-joint. They form two groups: the one, comprising the *muscular* branches proper, is composed of small twigs which supply the ham-string muscles; the other is composed of the two vessels known as the *sural arteries*, which supply the Gastrocnemius muscle. Each of these enters the head of the latter upon its own side, and extends along the muscle.

(*b*) The *lateral articular* arteries at the side of the joint consist of two pairs, as follows:—

(1) Superior Articular.
(2) Inferior Articular.

(1) The *superior articular* arteries arise above the line of flexion. They consist of an external and an internal artery. The *external* inferior articular artery passes upward and outward close to the femur to reach the Vastus Externus muscle to which and to the tendon of the Biceps its branches are distributed. The *internal* branch, also lying close to the bone, winds around to the inner side of the femoral condyle, and supplies the muscles inserted into the inner tibial tuberosity. Its terminal branches pass anteriorly as far as the patella.

(2) The *inferior articular* arteries also embrace

[1] Zaaijer, Journ. of Anat. and Phys., i. 180.

an external and an internal branch. Both vessels arise below the line of flexion of the knee-joint, and often pursue an oblique course downward and outward. The *external* inferior articular artery passes to the outside of the joint beneath the accessory external lateral ligament, and along the outer border of the external semilunar cartilage to the upper border of the Popliteus muscle. It here divides into twigs which supply the tendons of the Biceps, the Gastrocnemius, and the Plantaris muscles. The *internal* branch passes downward to the inner tibial tuberosity, around which it winds to yield small branches to the inner head of the Gastrocnemius and to the muscles inserted into the head of the tibia.

(*c*) The *median articular* artery is often a branch of the superior external articular artery. It pierces the capsule above the oblique fasciculus and, dividing, into branches, supplies the crucial ligaments and the synovial folds.

The *popliteal space*, or ham, is that lozenge-shaped space defined by the Biceps Femoris and Plantaris muscle to its outer side, by the Semimembranosis and the Semitendinosis, with the inner head of the Gastrocnemius to the inner side. The upper or proximal end of the space corresponds to the beginning of the lower fourth of the femur; the lower or distal end corresponds, nearly, to a girdle drawn round the leg at the level of the tubercle of the tibia. The floor of the popliteal space above the knee-joint is the femur, at the knee, the posterior capsule of the joint, and below the knee-joint, the upper portion of the interosseous space.

The more important contents of the popliteal space are the popliteal artery, the popliteal vein, the internal and external popliteal nerves, and lymphatic glands.

Relations.—As the artery lies on the femur, the vein lies close to its outer side, and the internal popliteal nerve passes well to its outer side, and more superficial to the plane of the artery. As the artery lies upon the capsule of the knee-joint, and on the space below the joint, the vein lies upon it. The internal popliteal nerve lies more superficially to its outer side. On the same plane with the nerve on either side of the artery are the nerves and vessels for the Gastrocnemius and Soleus muscles.

Remarks.—The popliteal artery suffers from the effects of diseased action and violence more frequently than any large artery of the limbs. The position of the vessel on the femur and the posterior ligament of the knee-joint will produce symptoms referable to these structures, if an aneurism projects from the anterior aspect of the vessel. In such instances the femur may be eroded, the capsular ligament destroyed, and the knee-joint entered. When the aneurism lies upon the posterior aspect of the vessel, it is apt to incline toward the inner side, and may form, in addition to the fulness of the ham, a swelling of the thigh at its lower third. Since it is in the latter locality that the inflammatory swelling occurs, dependent upon femoral necrosis, the two conditions should be carefully distinguished from each other. The sequestrum of femoral necrosis may wound the popliteal artery, as shown in the following case as recorded by Mr. Porter, of Dublin: A youth of fifteen years suffered from necrosis at the inner side of the femur at its lower third, where a sequestrum formed. At the age of twenty-nine, a traumatic popliteal aneurism was developed from the irritation of the sequestrum. The sac ulcerated and hemorrhage ensued. The parts being examined after amputation, the artery was found lacerated a little below its origin.

A similar lesion from the end of a fragment in a broken femur is described by Heath.[1] The artery was found ruptured opposite the origin of the median articular branch. Neither the nerve nor the vein was injured.

If the popliteal artery be torn across above the bend of the joint, the resultant tumefaction is extensive and superficial. If below the joint, beneath the heads of the Gastrocnemius, the blood will diffuse itself between them, elevate the muscles of the calf, and cause uniform and general enlargement of the upper part of the leg, and thus aid in concealing the condition. The blood from such a lesion may pass down as far as the tendo Achillis, or become superficial at the lower part of the Gastrocnemius and the Soleus. According to Pollock,[2] if the condition is chronic, and the contents of the tumor fluid, the muscles may become atrophied from pressure and fluctuation be present.—The author saw two instances, during the American civil war, of division of the popliteal artery by bullets. In both cases the parts distal to the division mortified and amputation was necessitated.

The artery may be involved in the late stage of suppuration in the knee-joint.

Ligation of the Popliteal Artery.—The vessel can be secured at its upper and lower portions. The middle portion, by reason of the character of its association with the posterior aspect of the capsule of the knee-joint and with the vein, is never ligated.

Ligation of the upper portion. The patient being placed upon his abdomen, and the limb extended, an incision three

[1] Lancet, Aug. 1868, 246.

[2] Guy's Hosp. Rep., 1866, 247.

inches in length is made along the tendon of the Semimembranosus muscle, as it forms the median boundary of the popliteal space. The superficial fascia being divided, the underlying Adductor Magnus is drawn inward. The popliteal nerve lies close to the muscle, and should be carefully isolated and drawn outward. The artery and vein are now exposed lying together, the vein inclining to the outer side of the artery. The needle should, therefore, be passed from without inward.

Ligation of the lower portion. A longitudinal incision three inches in length, beginning at the bend of the knee, is made in the middle line of the space between the heads of the Gastrocnemius muscle. The superficial fascia being divided, the short saphenous vein and nerve are seen and carefully drawn to one side. Separating the two heads of the Gastrocnemius with the handle of the scalpel, the vessels and nerve are seen lying at the bottom of the wound.

The vein and nerve are either both drawn inward, or they are separated, the nerve being drawn inward and the vein outward. The vein lies nearly over the artery, inclining somewhat to the outer side.

The *collateral circulation*, after ligation of the popliteal artery, may be not unlike the plan observed by Gruber[1] in the body of an old man. The main vessel was obliterated in the popliteal space, its remains lying in the inner popliteal sulcus. The volume of blood was carried by the gastrocnemial artery, which was enormously enlarged. The posterior tibial artery was derived from anastomosing branches from the preceding, and was efficient.

Variations.—When the femoral artery is absent, or does not reach the ham, the popliteal artery is a continuation of the ischiatic. The artery in this event lies superficially to the vein. It may be shorter than usual, the division into the terminal branches taking place at the upper part of the Popliteus. Or the artery may be longer than usual, and divide at the middle of the leg. A stout branch (short saphenous) may accompany the short saphenous vein, and, winding round the external malleolus, reach the foot to anastomose with the tarsal arteries. An accessory slip of the Gastrocnemius muscle may pass between the popliteal artery and vein.

THE POSTERIOR TIBIAL ARTERY.

The Posterior Tibial Artery is the larger of the two terminal branches of the popliteal artery. Beginning at the lower border of the Popliteus muscle, the artery descends the leg a little obliquely downward and outward, but soon becomes vertical, and lies at first upon the Tibialis Posticus, and afterward upon the Flexor Longus Digitorum. It passes behind the internal malleolus and terminates beneath the origin of the Abductor Pollicis, by dividing into two branches the internal and external plantar arteries.

[1] Virchow's Archiv, 1875, 262, figs.

The vessel ends at the middle of a line drawn from the tip of the internal malleolus to the middle of the heel, an important fact to remember in shaping the flap in Syme's operation.

The branches of the posterior tibial are—

(*a*) Muscular.
(*b*) Peroneal.

(*a*) The *muscular* branches as a rule are small. They are distributed for the most part to the deep and superficial muscles. Those to the Soleus are larger than those to other parts, save at the lower portion of the artery. Just before the origin of the plantar arteries a small branch is given off to the internal malleolus, and another to the inside of the calcaneum, to anastomose with the posterior peroneal and internal malleolar arteries respectively.

(*b*) The *peroneal* artery is the largest of the branches of the posterior tibial. It arises from the artery about one inch below the Popliteus muscle, at the origin of the Tibialis Posticus muscle, and about three inches below the level of the head of the fibula. It passes downward and slightly outward to reach the inner side of the fibula, along which it descends, either between the Flexor Longus Pollicis and the Tibialis Posticus, or within the substance of the former muscle. Toward the lower portion of the leg it passes beneath the peroneal muscles, crosses the tibio-fibular articulation, and descends behind the outer malleolus and the tendo-Achillis to supply the outer surface of the calcaneum, the adjacent fat, and the origin of the Abductor Minimi Digiti and the Flexor Brevis Digitorum.

The peroneal artery below the origin of the anterior peroneal is described by some authors under the name of the *posterior peroneal.* The branches of the peroneal are—

(1) Anterior Peroneal.
(2) Transverse.
(3) Nutrient.
(4) Muscular.

(1) The *anterior peroneal* is very variable in size. As a rule it arises about two inches above the ankle-joint under cover of the Peroneus Tertius. It pierces the interosseous membrane, supplies the ankle-joint, and anastomoses with the anterior tibial artery, and, in front, with the tarsal arteries.

(2) The *transverse* artery is a small branch arising from the peroneal a short distance above the anterior peroneal. It passes across the interosseous membrane to anastomose with the posterior tibial.

(3) The *nutrient artery* enters its appropriate foramen upon the posterior aspect of the tibia below the

oblique line, and supplies the interior of the bone. Before its entrance it gives a small twig to the periosteum, to the Tibialis Posticus, and to the Flexor Longus Digitorum muscle. The nutrient artery is relatively of large size, and may be a branch of the anterior tibial artery.

(4) The *muscular* branches supply the Soleus, the Flexor Longus Pollicis, and the Tibialis Posticus.

Relations.—*In the leg* the posterior tibial artery is crossed at its origin by the tendinous arch extending between the upper slips of origin of the Soleus muscle. The artery lies at first upon the Tibialis Posticus and upon the Flexor Longus Digitorum, and to their outer side at the lower third of the leg. The vessel is covered in the leg by the posterior tibial aponeurosis and by the muscles of the calf lying between this membrane and the skin. The vessel is accompanied by *venæ comites* and by the posterior tibial nerve, which lies chiefly to its outer side. *At the ankle*, the artery lies between the sheath inclosing the Tibialis Posticus and the Flexor Longus Digitorum, and that of the Flexor Longus Pollicis, the last-named muscle lying on the deeper plane. The artery is covered by the posterior tibial aponeurosis and by layers accessory to the annular ligament and the tendo-Achillis. *At its termination* the artery lies beneath the origin of the Abductor Pollicis, the skin, and the fascia.

Remarks.—In an aneurism of the posterior tibial artery recorded by W. Adams,[1] the tumor was situated on the posterior aspect of the bones of the leg, and protruded anteriorly between them. The fibula was bent perceptibly outward; the tibia slightly inward. The deep layer of muscles was for the most part displaced. The Flexor Longus Pollicis was superficial, while the Tibialis Posticus appeared expanded equably around the tumor. Ribes attributes the powerful contraction of the arteries in amputation of the upper part of the leg to the position of the end of the popliteal artery on the upper part of the interosseous ligament, a fixed point against which the vessel contracts.[2]

The artery may be distended or torn in lateral dislocation of the astragalus.[3]

Ligation of the Posterior Tibial Artery.—This vessel may be ligated at its middle and lower portions.

For *the upper portion* the limb is semiflexed and allowed to rest upon its outer side. An incision is made four inches in length parallel with the shaft of the tibia and a little to its outer side. The superficial fascia being exposed should be carefully divided, avoiding the internal saphenous vein and nerve which lie in the line of incision. The margin of the Gastrocnemius is then drawn to the outer side, and the tibial origin of the Soleus is next raised upon a director and divided the entire length of the first incision. The plane of the vessel is now reached, and the Soleus being drawn to the outer side, the vessel is felt lying under another thin layer of fascia overlying the Tibialis Posticus muscle. The vessel is carefully separated from its accompanying veins, and the needle passed from without inward. The large posterior tibial nerve lies to the outer side, and need not be injured.

By Guthrie's method the vessel is reached by an incision four or five inches in length, made the middle line of the fleshy part of the calf. The Gastrocnemius and the Soleus are freely divided until the plane of the vessel is reached. The remaining steps are as in the other operation. It is claimed for this procedure that it is less tedious and bloody, while the additional size of the wound, so far from being a disadvantage, favors drainage. In the first-named method an inexperienced operator is apt either to mistake the interspace between the Gastrocnemius and the Soleus for the plane of the artery, or to confound the tibial origin of the Tibialis Posticus muscle with that of the Soleus, and thus to get beneath the sought-for plane. In whatever way performed, the ligation of this portion of the vessel is justly held to be one of the most difficult of any required upon arteries of the lower extremity.

For ligation of *the lower portion*, namely, as the vessel lies behind the internal malleolus, an incision three inches in length is made midway between the malleolus and the heel. After dividing the superficial fascia, the annular ligament, which here represents the deep fascia, is next divided, while yet a third layer of fascia requires division before the vessel is reached. It is found with its accompanying nerve lying between the sheath of the Tibialis Posticus and of the Flexor Longus Digitorum muscles to the inner side, and that of the Flexor Longus Pollicis to the outer side. The nerve lies to the outer side, and need not be seen. Before ligation the artery should be next carefully isolated from the venæ comites.

Variations.—The posterior tibial artery may arise from the popliteal artery in the popliteal space. It may interchange with the peroneal, or unite with it by large transverse arteries, which may be held to be analogous to similarly placed vessels in the forearm, uniting the radial and

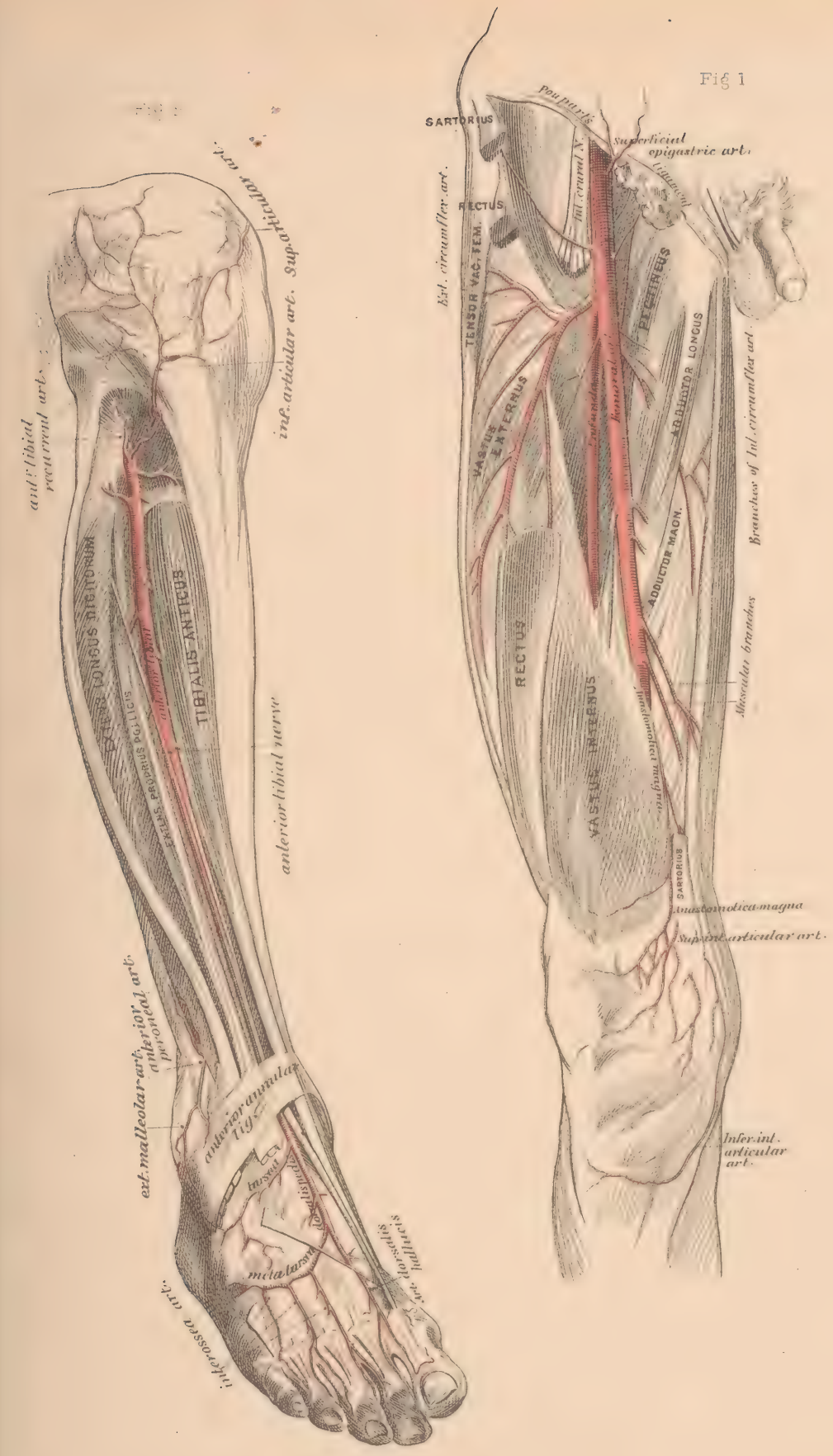
[1] W. Adams, Trans. Path. Soc. Lond., 1854, 11.
[2] Doane's Blandin, 345.
[3] Paul Broca, Mémoires de la Soc. Chir. Paris, iii. 1853.

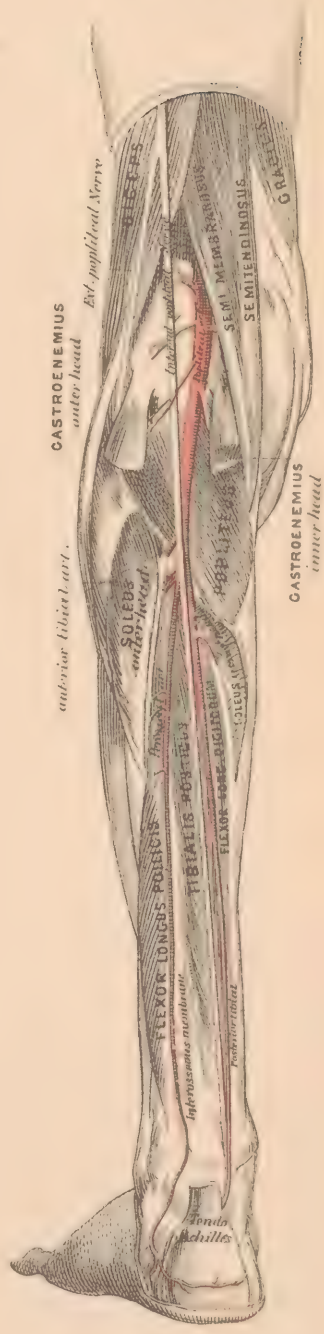
EXPLANATION OF PLATE LXX.

Fig. 1. The femoral artery and its branches.
Fig. 2. The anterior tibial artery and its branches.
Fig. 3. The posterior tibial artery and its branches.

PLATE LXX.

Fig 1





T. Sinclair & Son, Lith.

the ulnar arteries. The nutrient branch may arise from the anterior tibial. The plantar arch may be absent.

The peroneal artery is subject to relatively frequent variations. It may arise from the popliteal. It may interchange with both the posterior and the anterior tibial arteries in whole or in part. When the peroneal artery is absent, the posterior tibial artery yields the tibial nutrient artery. It may yield no branches until near its termination.

THE PLANTAR ARTERIES.

The Plantar Arteries constitute the terminal branches of the posterior tibial.

They are two in number, as follows—

(*a*) Internal Plantar.

(*b*) External Plantar.

(*a*) The *internal plantar* artery, the smaller of the two, extends along the inner side of the foot in the groove between the Abductor Pollicis and the Flexor Brevis Digitorum muscles. It is variable in its disposition, but as a rule divides into two branches, one of which extends along the upper border of the Abductor Pollicis, and is lost along the inner border of the great toe, where it joins the inner division of the first digital artery; while the other branch passes forward to join the first digital artery at its junction with the first perforating branch from the dorsal artery of the foot.

The internal plantar artery sends minute branches to the muscles along the inner border of the foot and to the tarsal bones and ligaments, and several cutaneous branches to the sole of the foot, as well as anastomosing branches which join the internal malleolar and the tarsal arteries.

(*b*) The *external plantar* artery arises from the posterior tibial, between the calcaneum and the Abductor Pollicis, under the annular ligament. It is directed outward and forward beneath the Flexor Brevis Digitorum and Accessorius to the septum between the former muscle and the Abductor Minimi Digiti. It here lies deep, and is deflected directly forward between these two muscles as far as the base of the fifth metatarsal bone, where it is curved inward between the flexors of the toes and the Lumbricales to enter into the plantar arch.

The external plantar sends off small *calcaneal branches* which cross the calcaneum at its under surface to supply adjacent parts and the integument, and numerous small *muscular branches* to supply the muscles along the outer border of the foot. Some of these anastomose with the tarsal arteries. A *digital branch* passes beneath the Abductor Minimi Digiti to the outer border of the fifth metatarsal bone.

According to Power, the artery as it turns inward lies in a triangular space, bounded in front by the Transversalis Pedis, behind and to the inner side by the Abductor Minimi Digiti, and to the outer side by the Flexor Brevis Minimi Digiti. The interosseous muscles lie above it, and the common flexor tendons beneath it. The external plantar nerve crosses to the inner side of the vessel.

The *plantar arch* is formed by the junction of the continuation of the external plantar artery with the first interosseous branch of the dorsalis pedis. It increases slightly in size from without inward. It passes over the bases of the metatarsal bones and tendons of adjacent muscles. The plantar arch yields four digital arteries which occupy the interosseous spaces. Each of the three outer digital arteries, as it reaches the metatarso-phalangeal articulation, constantly divides into two branches which supply the opposed surfaces of the corresponding toes. The first digital artery is much larger than the remaining three. It commonly divides into three branches: the one extends along the inner margin of the great toe, where it is often joined by the terminal twig of the internal plantar; the second supplies the outer margin of the great toe; while the third extends along the inner margin of the second toe.

In addition to the above, the plantar arch sends small branches backward, which supply the under surface of the tarsus and the associated ligaments; and three small branches upward, which perforate the interosseous spaces between the heads of the Dorsal Interosseous muscles, and anastomose with the dorsal arteries.

REMARKS.—The fact mentioned on page 204, that injuries of the median portion of the foot are, as a rule, of a graver nature than those of the lateral portion, can be explained in part by the small amount of blood which the median portion receives.

THE ANTERIOR TIBIAL ARTERY.

The Anterior Tibial Artery constitutes the anterior terminal division of the popliteal artery. It passes between the two upper slips of origin of the Tibialis Posticus muscle, and pierces the interosseous space just above the interosseous membrane to gain the anterior tibial region. It descends the leg, passing downward and a little inward to lie in front of the ankle-joint beneath the annular ligament, at the lower border of which it terminates in the dorsalis pedis. The vessel is at first deep-seated, and rests upon the interosseous membrane with the Tibialis Anticus muscle to the inner side, and the

Extensor Longus Digitorum to the outer. It becomes superficial at its lower fourth, where it lies upon the tibia between the tendons of the Extensor Longus Digitorum and of the Extensor Proprius Pollicis. It is crossed at the ankle by the tendon of the Tibialis Anticus muscle, and is here covered by the skin and fascia only.

A straight line drawn from the middle of the space between the head of the fibula and the tubercle of the tibia to the middle point of the intermalleolar space represents its course. Hyrtl and Henle describe the artery as passing in a fibro-muscular canal which is defined behind by the interosseous membrane, and in front by the fibres of origin of the Extensor Proprius Pollicis. The artery, vein, and nerve are inclosed in a kind of short tubular compartment opposite the ankle-joint.

The artery yields its larger branches at the upper and lower extremity of the leg. They are as follows:—

(*a*) Anterior Recurrent.
(*b*) Muscular.
(*c*) Internal Malleolar.
(*d*) External Malleolar.

(*a*) The *anterior recurrent*, always of considerable size, arises from the main vessel immediately after its appearance upon the front of the leg. It ascends obliquely upward and inward, through the substance of the Tibialis Anticus, to gain the internal tuberosity of the tibia, about which it is distributed after the fashion of a periosteal vessel. Its superior and larger branch runs along the outer border of the *ligamentum patellæ*, anastomosing with the inferior external artery. The inferior branch anastomoses with the internal articular artery.

Henle describes a *superior fibular artery* which winds around the head of the fibula under the origin of the Peroneus Longus.

It supplies these muscles and gives branches to the knee and to the superior tibio-fibular articulation.

(*b*) The *muscular branches* are numerous, but small. They supply the muscles and skin of the anterior tibial region. A few twigs pierce the interosseous membrane to supply both it and the Tibialis Posticus muscle.

(*c*) The *internal malleolar* is given off at the front of, and a little above, the ankle, between the tibia and the tendon of the Tibialis Anticus, where it divides into two branches, a *deep* or articular, and a *superficial*, which supply the periosteum of the inner malleolus and the inner side of the tarsus, and anastomose with the internal tarsal branch of the internal plantar artery, as well as with terminal branches of the peroneal artery.

(*d*) The *external malleolar*, somewhat larger, and placed a little lower than the preceding, is variable in its origin. As a rule it arises a short distance above the ankle-joint beneath the tendons of the Extensor Longus Digitorum and of the Peroneus Tertius muscles, passes downward and outward to supply the parts about the external malleolus and the outer aspect of the calcaneum, and anastomoses with the anterior peroneal, with the external tarsal, and with branches of the external plantar.

Ligation of the Anterior Tibial Artery.—The anterior tibial artery is secured at its upper part by making an incision parallel to the tibia in a line corresponding to the septum between the Tibialis Anticus and the Extensor Longus Digitorum muscles. This line can be defined by exciting contraction of the first-named muscle. The incision should be fully three inches in length. The deep fascia being divided, the muscles should be separated toward the lower end of the wound. If any small branches of arteries be seen beneath the fascia, they will serve to guide the operator to the anterior tibial, which lies with its accompanying veins upon the interosseous membrane, together with the nerve of the same name, the latter lying to the outer side of the vessel.

At the lower portion of the leg, the artery lies between the tendon of the Tibialis Anticus muscle and that of the Extensor Proprius Pollicis. Its relations are here essentially the same as at the upper part. The incision should be three inches in length along the outer margin of the Extensor Proprius Pollicis.

Remarks.—The vessel may be injured by the fragment of the fractured tibia. M. Verneuil reports an instance in which the artery was obliterated by the upper fragment of the bone, in a man aged forty-eight, with resultant gangrene of the limb below the injured point. Amputation was resorted to, but death ensued from pyæmia.

THE DORSALIS PEDIS.

This artery is the continuation of the anterior tibial upon the dorsum of the foot. It begins at the lower border of the annular ligament, and passes directly forward, crossing the second cuneiform bone nearly parallel to the inner border; it terminates in the first interosseous metacarpal space at the first metatarso-phalangeal articulation, where it divides into (*a*) the tarsal, (*b*) the metatarsal, (*c*) the dorsalis hallucis, and (*d*) perforating branches.

(*a*) The *tarsal* branch arises from the dorsalis pedis upon the scaphoid bone. It passes outward between the tarsal bones below and the Extensor Brevis Digitorum above, supplying that muscle as well as the

tarsal articulations. It anastomoses with branches of the metatarsal, the external malleolar, the peroneal, and the external plantar arteries.

(*b*) The *metatarsal* branch is not so large as the preceding. It curves outward at the base of the metatarsal bones, and sends three digital branches from the anterior portion of the curve, each of which divides a little beyond the base of the first phalanx into two branches which supply the opposed surfaces of the toes. The artery communicates with the plantar vessels by two minute perforating arteries to each interosseous space, which are termed respectively the anterior and the posterior perforating arteries.

(*c*) The *dorsalis hallucis* lies in the first interosseous space. It divides near the toe-cleft into two branches. Of these the internal passes under the tendon of the Extensor Proprius Pollicis, and gives off small vessels to the dorsum of the great toe. According to Power, it may be directed beneath the first metatarsal bone to supply the inner border of the great toe, there to anastomose with the internal plantar artery, and thereby completing the *plantar arch*.

(*d*) The *perforating* or communicating artery penetrates the first dorsal interosseous space to join the terminal branch of the external plantar artery.

Quain has described a plantar digital branch which crosses beneath the first metatarsal bone, and which runs along the inner side of the great toe upon its plantar surface.

Ligation of the Dorsalis Pedis.—Upon the instep, the artery is found between the Extensor Proprius Pollicis and the inner border of the tendon of the Extensor Communis Digitorum. The artery lies upon the first interosseous space. The line of incision extends from a point at the middle of the anterior intermalleolar space to a point between the anterior extremities of the first two metatarsal bones. An incision one inch long in the course of the line, or along the outer border of the tendon of the Extensor Proprius Pollicis, should be made, and, upon cutting through the skin, the superficial fascia, and the deep fascia, the artery is secured, after separating the accompanying veins, by passing the ligature from without inward.

Variations.—The artery may arise at a point in the popliteal space. It may pass with the cutaneous branch of the external popliteal nerve round the fibula, instead of piercing the interosseous spaces, and be parallel to the fibula, as far as the ankle, where it lies in front of the joint. In instances of absence of the posterior tibial artery the popliteal may divide into the anterior tibial and the peroneal arteries. The anterior tibial may become superficial at the middle of the leg, and thence to its termination be covered only by the fascia and the skin. The artery may be absent, when its place is taken in the leg by muscular branches of the posterior tibial artery, and in the foot by branches of the peroneal artery. The dorsalis pedis and the plantar arteries and their branches may interchange with one another.

THE VEINS.

The veins of the human body are of two kinds, the systemic and the pulmonary.

The *systemic veins* are those which receive the blood from the capillaries (excepting those of the lungs), and convey it to the right auricle of the heart.

The *pulmonary veins* are those which receive the blood from the capillaries of the lungs, and convey it to the left auricle of the heart. These have been already described (p. 351).

THE SYSTEMIC VEINS.

The systemic veins are divided into two groups. The first of these groups embraces the veins employed in collecting blood from the extremities, the head and the neck, the chest walls, and the pelvic organs.

The second, commonly called the portal system, includes the veins conveying the blood from the alimentary canal and related abdominal appendages (organs of chylifaction) below the Diaphragm, as well as the spleen.

Terms Used in Describing the Veins.

A Radicle. A small vein which forms the root or one of a number of peripheral branches to a main trunk.[1]

[1] The "root" of an artery is its cardiac end. The "root" of a vein is its peripheral end.

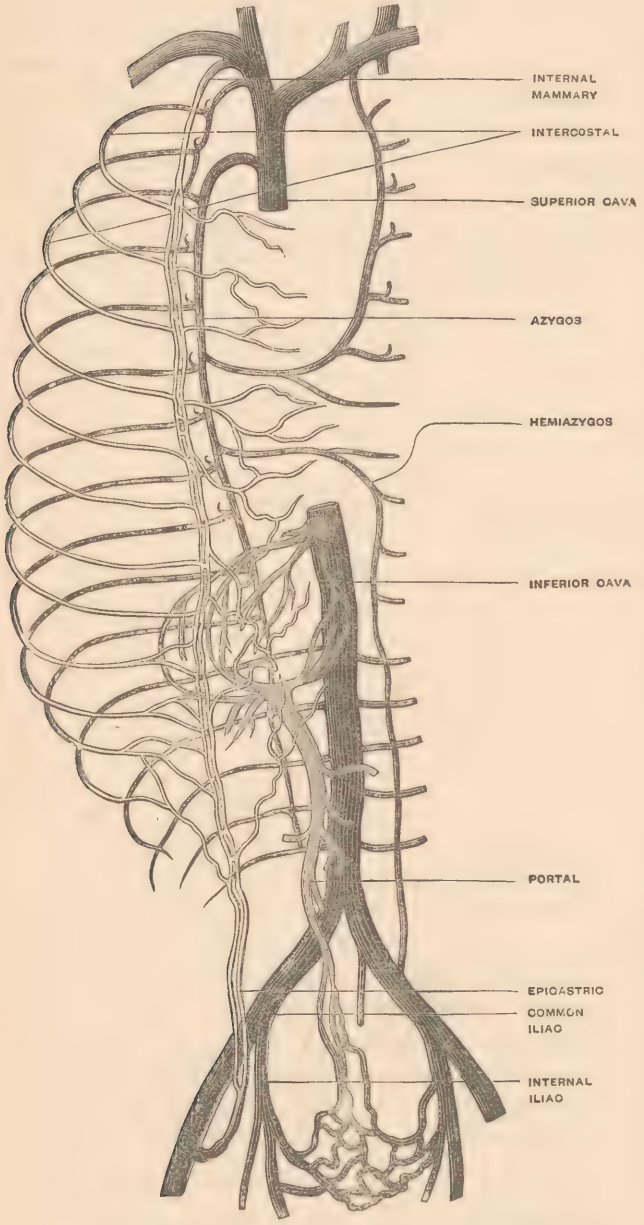
A Venule. A small vein. It may be either a radicle or an anastomotic branch.

A Tributary. Any vein received into another.

A Sinus. Any dilatation of a large vein receiving tributaries. The best illustrations are the sinuses of the dura mater, and the coronary sinus of the heart.

A Lacuna. A widened avenue of communication between an artery and a vein, which takes the place of a capillary network.

Fig. 84.



Diagrammatic Representation of the Veins of the Trunk.

The Development of the Greater Veins.

In order to explain the development of the larger veins and their disposition in the body, some account is necessary of the circulation of the blood in the embryo.

When the fœtus is in intimate relation with the yolk-sac, the circulation of the blood is said to be *vitelline*, and to be composed of the *omphalo-mesenteric* arteries and veins with the intervening network.

When the allantois is in contact with the uterine wall, the circulation is said to be *placental*, and to consist of the hypogastric arteries, of the umbilical vein, and of the intervening capillaries or lacunæ. (See account of the Fœtal Circulation.)

When the lungs are functionally active, the circulation is said to be *terrestrial*, or that of the adult, and to be carried on by the arteries and veins of the body as described without qualification.

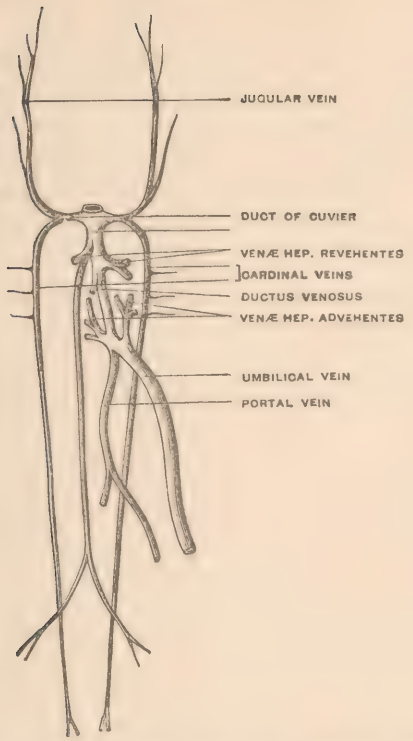
An actively developing organ requires numerous or large bloodvessels. Reduction in the size of the organ, or diminution in its activity, allows corresponding changes to take place in its bloodvessels. Should the organ disappear, the vessels will become obliterated. The manner in which the arterial system of the adult is evolved from the system of the cervical arches in the embryo has been described elsewhere (p. 346). It remains to show in what direction the venous system is changed during development.

The disposition of the larger venous trunks is determined by two active processes: one of these represents the growth of the brain; the other, the growth of the nutritive appendages, by which term are meant the organs, temporary or permanent, which secure food-material to the developing organism.

The brain of the young embryo is developed anteriorly to a greater degree than it is posteriorly. The venous blood flowing from it tends to escape at a point in advance of the posterior jugular foramen of the adult; namely, from an opening in front of the temporal bone. The trunk which is formed for its reception receives the name of the *primitive jugular vein*, and carries the greater portion of the venous blood from the brain-case until the development of the organ is completed, when its place is taken by the *internal jugular vein*. The trunks of the internal maxillary and the external jugular vein of the adult are supposed to be survivals of the primitive jugular vein.

The two primitive jugular veins descend the neck and enter the thorax, where they unite with the *cardinal veins*, the short horizontal trunk resulting from this union forming the *ducts of Cuvier* (canals of Cuvier), which empty into the single auricle of the heart. A small *transverse vein* (cross-branch) unites

Fig. 85.



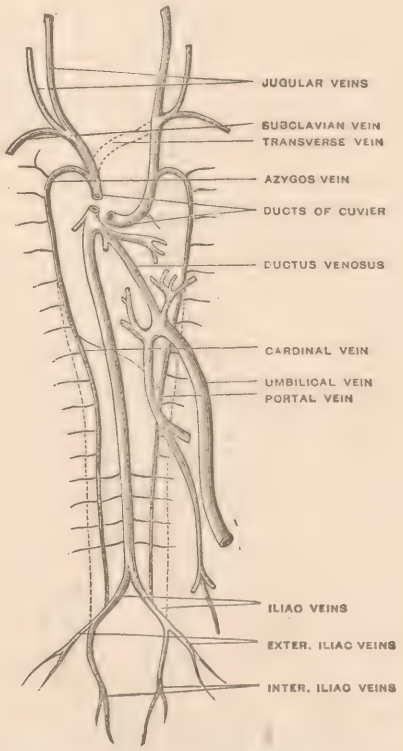
A Plan of Principal Veins of the Fœtus of about Four Weeks.

the primitive jugular veins at about the point where they become thoracic. The *cardinal veins* (vertebral veins) are two in number, the right and the left, their presence being determined by the activity of the Wolfian bodies. Accessions are received by the main vessels from the vertebral intercostal and lumbar veins. The cardinal veins ascend to join the primitive jugular veins, to form, with the assistance of the primitive jugular veins, the *ducts of Cuvier*. The lines of continuity from the right and left primitive jugular veins constitute in the thorax the right and left *fœtal venæ cavæ*.

Independently of the formation of the primitive jugular veins, the cardinal veins, and the ducts of Cuvier, blood is collected from the vitelline sac or its rudiments, and from the umbilical vesicle, to form the *right* and the *left omphalo-mesenteric* veins, which together form a short trunk to empty into the auricle of the heart. In the formation of this trunk, the initial step is taken toward the separation of a distinct trunk for the conveyance of blood to the heart from its source outside of the trunk. After the disappearance of the umbilical vesicle, the right and left omphalo-mesenteric vessels, for the most part, disappear also, the proximal portion of the left trunk alone persisting to receive the blood collected from the placenta. The right and left veins now receive the name of the *umbilical* veins, which unite in the trunk representing the remains of the omphalo-mesenteric system to form the *common omphalo-mesenteric* trunk. (See p. 395.)

The liver is an organ of great activity from the time of the development of the vitelline circulation. The venous current from the source of nourishment, whether that be in the vitelline sac, in the placenta, or in the intestinal tract, passes through a capillary system in the liver, but is again collected by one or more trunks which pour the return venous blood into the heart. The manner by which the blood is received and transmitted through the liver is essentially the same from the period of the vitelline circulation to adult life. In the vitelline type, the branches of the omphalo-mesenteric vein, as it enters the liver, form two main trunks which are called the *venæ hepaticæ advehentes*, while those which collect the blood from the hepatic capillaries are called the *venæ hepaticæ revehentes*. This arrangement is modified in the placental circulation by the common trunk of the omphalo-mesenteric vein receiving the blood from the umbilical vein, and in addition from the portal vein, which is as yet a small trunk. Finally, when the placental circulation is

Fig. 86.



Plan of the Principal Veins of the Fœtus at the time of the first Establishment of the Placental Circulation.

well established, the venæ hepaticæ revehentes form a distinct trunk, which receives the name of the hepatic vein, and opens, not into the heart, but into the inferior vena cava; and a new trunk appears, the *ductus venosus*, which connects the hepatic with the umbilical vein. After birth the umbilical vein and the ductus venosus disappear, and the portal vein alone carries blood from the sources of nutrition to the heart by way of the hepatic capillaries, the hepatic vein, and the inferior cava.

During the period in which the nutritive veins are being elaborated, the blood is returning from the developing limbs, and in the end it materially modifies the arrangement of the cardinal veins and the primitive jugulars. The thoracic trunk of the right primitive jugular becomes the *right innominate vein* and the *superior vena cava*. The left thoracic portion of the primitive jugular disappears, the small transverse vein taking its place, and forming the *left innominate vein*, which joins the superior cava just before this vessel becomes continuous with the right duct of Cuvier. The thoracic portion of the left primitive jugular persists as a small vein, the *vestigial vein* (q. v.), which empties into the coronary sinus.

The blood from the inferior extremity finds no trunk in the abdomen prepared to receive it save the pelvic radicles of the cardinal veins, which, by appropriate enlargement, would be competent to return the blood to the duct of Cuvier. But the retrograde tendency of these veins attending the process of atrophy of the Wolfian body is so pronounced, that they are unable to fulfil this new task. A new trunk appears for the purpose, namely, the *inferior vena cava*, a trunk which, at the same time that it conveys the blood from the extremities, also receives some of the detached radicles of the cardinal veins in the shape of the internal iliac veins. It also receives tributaries from the kidneys, the testes, the ovaries, the suprarenal bodies, and from the liver through the right hepatic vein.

The persistent trunks of the cardinal veins are seen in the developed body as the *azygos* vein, which represents the right cardinal vein, and as the *hemiazygos*, which represents the left cardinal vein.

Regarded in the light of the above facts, the veins of the body are of different degrees of significance.

The external jugular represents the cervical portion of the primitive jugular vein.

The main portion of the superior vena cava represents the thoracic portion of the right primitive jugular.

The vestigial vein represents the primitive right vena cava.

The termination of the superior vena cava in the right auricle represents the right duct of Cuvier.

The azygos vein and the hemiazygos vein, together with the internal iliac veins and their tributaries, represent the remains of the cardinal system of veins.

Variations.—It is evident, from the statements already made, that the study of variations in the trunkal veins involves the entire life-history of the organism. The recorded malformations of the greater veins are capable of being grouped under nine distinct heads or types, as follows:—

(1) The transverse vein is absent or much reduced in size.

(2) While the transverse vein is normal, the left duct of Cuvier persists.

(3) Anastomoses exist between the superior vena cava and the pulmonary veins, or a communication exists between the superior vena cava and the left auricle.

(4) The inferior vena cava is absent. The common iliac vein opens either into the corresponding enlarged right, or into the left, cardinal vein.

(5) The lower portion of the left cardinal vein is enlarged between the renal and common iliac veins.

(6) One of the cardinal veins supplants in part the cardinal vein of the opposite side of the body.

(7) The omphalo-mesenteric vein persists.

(8) The umbilical vein persists, wholly or in part.

(9) The hepatic veins terminate in exceptional places.[1]

That variations in the veins are correlated with defects in the visceral apparatus must be, from the preceding statements, a self-evident proposition. Recorders of malformations or varieties have too often neglected to mention the related defects or peculiarities accompanying the arrangement of the venous trunks themselves. It is evident that a narrow or enlarged internal jugular vein will be found associated with corresponding changes in the sinuses of the dura mater, and both of these again, most probably, with peculiarities of brain-structure, or retarded rates of brain-growth.[2] It is well known that variations of the azygos vein in the thorax are apt to be associated with the presence of supernumerary lobes in the lungs. The kidney has been found absent in connection with some variations of the inferior vena cava, and the thymus gland duplicated in subjects presenting variations of the left innominate vein, etc.

[1] See W. Krause, in Henle's Anatomy, iii. 379, for an exhaustive treatment of the subject, with copious references.

[2] The disposition of the veins carrying blood from the brain, especially those perforating the squamous portion of the temporal bone, has systemic significance in the mammalia.

Many minor variations of the veins of the limbs are due to the same general causes as those affecting the accompanying arteries. The regions of the joints, and the regions of junction of the limbs with the trunk, are favorite localities for venous as well as for arterial variations.

Those veins which are early formed, and are not subject to change afterward, present comparatively few variations; such, for example, are the vertebral and intercostal veins. In those, on the other hand, such as the cervical veins, which depend upon the differing rates of development of the various parts of the brain and face; or in those in the abdomen where gross changes in visceral development are being effected, variations are of common occurrence.

Owing to the free anastomosis between the minor vessels of the venous system, collateral circulations are established with relative ease in the veins, even after the occlusion of the larger trunks.

The veins generally accompany the arteries of the same name. Each arterial twig is usually accompanied by a single vein. The veins of muscles exhibit irregularities of calibre, which, however, abruptly disappear as the veins emerge from the muscle. In passing through fibrous rings or bands they enlarge below and become narrow above them.

When venæ comites are present about an artery, it has been found, as a result of Verneuil's researches,[1] that the larger of the two veins is alone furnished with valves, and that the collateral vein joins the main vessel above the position of the valves by small transverse veins. Verneuil proposes to apply the term *segment of security* to the space between any two sets of valves; and he believes that the collateral and transverse veins are able to relieve a given segment of security of excess of blood, and to carry it forward to the heart, or to pass it to the adjoining cardiac segment of security.[2]

THE SUPERIOR VENA CAVA.

The Superior or Descending Vena Cava extends from the termination of the two innominate veins to the right auricle. It is a large trunk measuring from two to three inches in length, and is directed downward, nearly vertically, or with a slight curvature to the left side. It lies behind the right border of the sternum, and extends from the first right costal cartilage to the middle of the second intercostal space, or to the third rib. It is embraced at its lower third by the pericardium, the serous lining of which is in relation with its front and sides. It lies in front of the trachea and the root of the right lung, having the aorta to its left, and the right lung to its right side.

The two innominates in rare instances pass directly downward to the right auricle. This is the normal arrangement in some animals, as the monotremes, marsupials, bats, most rodents, and some insectivores. Under rare conditions the right pulmonic veins empty into the superior vena cava near its termination in the right auricle.[1]

Relations.—In addition to the relations given above, the superior vena cava has the right pleura and lung, and the right phrenic nerve to its right side, and the ascending portion of the aorta to its left. The right azygos vein, a portion of the trachea, the right pneumogastric nerve, and a few lymphatic glands lie behind.

The *Variations* of the superior vena cava are best explained by reference to the retention of parts of the ducts of Cuvier.[2] It has been known to receive one of the pulmonary veins. In rare cases, where it has been doubled, the azygos vein commonly joins the right vein, which is the true cava, the left being continued to the left auricle.

Remarks.—Enlarged lymphatic glands may press upon the superior cava, but not with sufficient force to obliterate its lumen. Such pressure may so retard the downward flow of the blood as to render the face œdematous, especially the eyelids, and to render the complexion livid.

If the pressure is sufficiently great, the whole of the return blood is compelled to seek a new channel. The dilated right vena azygos in some degree supplies this, joining, as it does, the lumbo-vertebral plexus and the internal mammary and deep epigastric veins. The enlargement of the last-mentioned vessels is at times a conspicuous sign during life of pressure upon the superior cava. The right vena azygos and its tributaries may be found much enlarged, but the terminal portion of the vein may be impervious. The blood from the azygos vein may reach the right auricle by means of a vessel joining the superior cava at its upper part, and by another which may pass downward through the aortic opening and unite with the inferior vena cava.

T. Henry Green[3] reports in detail the effects of constriction of the superior vena cava in a man forty-four years of age. The vessel was found to be completely impervious for about one-and-a-half inch from the auricle. Beyond this point its diameter was about one-sixth of an inch, and its walls were apparently thickened. A dense mass of adventitious new growth embraced the vessel, and was

[1] Bull. de la Soc. Anatomique, t. xxxvi. 1861, 268.

[2] For additional remarks on Veins, see p. 338.

[1] W. Gruber, Virchow's Archiv, Bd. 68, 284, fig.

[2] See p. 412; also Krause in Henle's Anat.

[3] Trans. Path. Soc. London, 1876, 118.

doubtless the cause of constriction. During life it was observed that the capillaries of the face had always been dilated, and the skin livid. The skin of the chest above the level of the Diaphragm was studded with clusters of dilated capillaries, the largest collection being over the cartilages of the left false ribs.—Aortic aneurism may rupture into the superior vena cava.

The superior cava was found by Wharton[1] completely torn off from the heart, in a woman who had been injured by a wagon passing over the trunk. In this case no bones were broken, nor was other serious lesion incurred.[2]

THE INNOMINATE VEINS.

The Innominate Veins (brachio-cephalic veins) are two in number, the right and the left. They are not symmetrical, the left being the longer. Each vein is formed by the union of the internal jugular and the subclavian vein of the corresponding side, and extends from the inner extremity of the clavicle downward to unite with its fellow at a point nearly opposite the first intercostal cartilage of the right side. It will be seen, therefore, that the right vein is nearly vertical, while the left inclines downward and toward the right. The right vein receives the right thoracic duct, and the left the main left or thoracic duct.

To the outer side and somewhat in front of the right innominate vein lies the right lung. To its inner side is the thoracic aorta; and in front, the cartilage of the first rib, together with the slips of origin of the Sterno-Hyoid and the Sterno-Thyroid muscles.

The left innominate vein crosses the innominate artery and the left carotid artery, as they arise from the arch of the aorta. It has an indirect relation with the left subclavian, and lies directly between the first-mentioned vessels and the manubrium of the sternum.

The veins opening into the innominate are the same on both sides, viz.:—

From above	Inferior Thyroid.
	Vertebral.
	Deep Cervical.
From below	Superior Intercostal.
	Internal Mammary.
	Thymic.
	Bronchial.
	Mediastinal.
	Pericardiac.

The *inferior thyroid* vein arises from the lower part of the thyroid plexus. The right vein inclines to the right side, while the left is nearly in the median line.

The *vertebral* vein accompanies the vertebral artery. It arises by tributaries about the foramen magnum, and anastomoses with the vertebral plexus. Descending the canal for the vertebral artery, the vein escapes at the foramen in the transverse process of the sixth cervical vertebra. The vertebral vein may be received by the subclavian. The veins about the anterior condyloid foramen may open into the vertebral vein, and others may join the posterior spinal plexus.

Remarks.—Deep wounds of the neck may be accompanied by venous bleeding of unexpected severity, if any of these directly communicating branches of the vertebral vein be divided. Pitha[1] records a fatal case due to inflammation following a wound in the neighborhood of the mastoid foramen, and thence involving the emissary veins. Luschka suggests that cupping and leeching at the back of the neck may relieve congestion of the pharynx.

The *deep cervical* vein lies between the Multifidus Spinæ and the Semispinalis muscles. It anastomoses with the occipital, and empties into the innominate vein to the outer side of the vertebral. Struthers[2] describes this vein as furnished with a valve. It often unites with the vertebral near its termination.

The *superior intercostal* vein collects blood from the upper intercostal spaces. Its relations with the azygos veins (q. v.) are important.

The *internal mammary* veins accompany the artery of the same name, as venæ comites. They unite into a single trunk immediately prior to their termination.

The positions and functions of the remaining veins are expressed in the names they bear, and do not require separate description.

Remarks.—The left innominate vein in young subjects is placed at a higher plane than in adults, and, like the innominate artery, may form one of the component parts of the pretracheal space. Mr. Whillie mentions a case of a practitioner who, in performing tracheotomy upon a man apparently drowned, unwittingly opened this vein.

From the position of the innominate veins, with respect to the great vessels, it is evident that they may be compressed by aneurismal tumors. Dr. W. H.

[1] Dub. Quarterly Journ., xlix. 1870, 501.

[2] For additional clinical literature see T. Thurnam, Med. Chir. Trans., xxiii. 1840, 344.

[1] Œst. Zeit. für prackt. Heilkunde, i. 1859.

[2] Edinburgh Med. Journ., 1856, 418.

Van Buren[1] describes an instance of aneurism of the descending aorta, in which the right innominate vein was obliterated. Œdema of the right upper extremity had been noticeable during the life of the patient. The left subclavian vein was greatly dilated.

Owing to the intimate relations existing between the right innominate vein and the lung of the corresponding side, the products of inflammation in pneumonia or in pleuritis may press against the vessel and interfere with the return of venous blood to the heart from the arm, the neck, and the head.

Variations.—The superior vena cava may be absent, when the innominate veins open separately into the right auricle. The thyroid, intercostal, and mammary branches may join the superior vena cava. The left innominate vein may pass through the thymus body.

THE VEINS OF THE HEAD AND THE NECK.

The veins of the Head and the Neck may be described separately, as follows:—

I. The Veins of the Head.

The Veins of the Head include—

I. The External Veins.
II. The Encranial Veins.

I. The External Veins are—

Facial.
Temporal.
Internal Maxillary.
Temporo-Maxillary.
Posterior Auricular.
Occipital.
Lingual.
Pharyngeal.

The Facial Vein (anterior facial) arises by the angular vein at the side of the root of the nose. Lying to the outer side of, or behind, the facial artery, though less tortuous than that vessel, it descends obliquely downward and outward to the lower jaw, which it crosses in front of the Masseter muscle, to appear upon the neck. It here terminates in the *temporo-maxillary* or *common facial* vein. Upon the face it is surrounded by subcutaneous fat, and lies beneath the Zygomaticus Major muscle; but on the neck it lies beneath the superficial fascia and the Platysma Myoides muscle.

The tributaries of the facial are the *frontal*, which descends the forehead; the *supraorbital*, which passes inward along the upper eyelid and the brow; the *inferior palpebral*, the *dorso-nasal*, the *vena alæ nasi*, the *superior* and *inferior labial*, the *buccal*, *masseteric*, *palatine*, *ranine*, and *submental* veins. The *palatine* derives blood from the soft palate and the tonsil; the *ranine* from the tip of the tongue. The submental vein answers in position to the submental artery, and derives blood from the submaxillary gland and the Mylo-Hyoid muscle.

The facial vein anastomoses with the anterior branches of the infraorbital, with the pterygoid branches of the internal maxillary, and, through its anterior and transverse branches, with the temporal veins.

Remarks.—It will be seen that the venous supply of the face differs in some important particulars from that of the trunk and limbs. In the last-named localities, both deep and superficial currents flow in the same direction towards the heart. The facial trunk, however, is not formed by primal venules, as is commonly the case, but by branches communicating with the frontal and supraorbital veins, and by a transverse branch found at the bridge of the nose. It is highly probable that much of the blood of the interorbital space and of the locality about the inner canthus of the eye flows through the orbital conduits to the cavernous sinus. Further down the face, it is seen that the infraorbital artery alone of all the vessels of the face possesses venæ comites. These promptly join the orbital set of veins, or aid in swelling the volume of the internal maxillary vein. The veins corresponding to the deep parts of the face, other than those mentioned, also seek an outlet in the same trunk, so that much of the superficial blood of the upper part and side of the face passes *inward* to the brain-case and to the interior of the facial region, while the remaining portion flows *downward* to join the external and the anterior jugular veins.

It is of interest to note that in facial phlebitis the disease has a tendency to extend upward, except when the exciting cause lies at a point in or about the lower lip, in which case, as a rule, the inflammation extends downward. In a case reported by M. Bechez,[1] illustrative of the fact just stated, a soldier, aged forty-two, was attacked with fever, followed by redness and slight swelling of the forehead. This swelling soon became more pronounced along the course of the temporo-frontal veins, which were hard, prominent, and of a violet color. The eyelids were œdematous,

[1] New York Journ. of Med., 1849, 203.

[1] Gaz. Heb., 1863, 716.

and the conjunctiva chemosed. The patient died about the seventh day. A somewhat similar case, recorded by Mr. T. H. Sylvester,[1] is interesting from the fact that the frontal veins determined the extent of the inflamed tract. A puncture of the lip excited the phlebitis, which extended to a small vein at the outer side of the nose, thence to the inner canthus, and from that point along the frontal vein to the scalp, which became extensively infiltrated with pus. The case terminated fatally at the end of five weeks.

The relations existing between the venous blood of the face and that of the brain-case are rendered evident by the fact that the state of the circulation of the external nose is sometimes an index of the condition of the vessels of the brain.

The Temporal Vein (posterior facial) originates in the region of the temple, by branches answering to the position of the anterior and the posterior temporal arteries; the anterior branch anastomosing with the frontal, and the posterior with the occipital and posterior auricular veins. The vein descends over the root of the zygoma and passes through the parotid gland, as far as the angle of the lower jaw, where it terminates in the external jugular vein. Just before its termination, it sends forward a large branch (the communicating branch) which joins the temporo-facial. Quain describes the main trunk as dividing, one branch going to the facial, the other to the external jugular vein.

The temporal vein receives the following tributaries: The *middle temporal*, which originates in the Temporal muscle, and pierces the temporal fascia just above the zygoma, to reach the temporal vein; sometimes the middle temporal joins the deep temporal veins, which are tributaries of the internal maxillary; the *anterior auricular* vein, from the external ear; the *parotid* branches from the parotid gland; and the *transverse facial*, which accompanies the artery of the same name. The most important tributary, however, is the *internal maxillary* vein.

Remarks.—Plexiform nævus, formed by branches of the temporal vein in the parotid gland, is sometimes recognized in the living subject. It is always a serious condition, not only because of the difficulties attending an operation for its removal, but because of the pressure often exerted upon the pharynx and associated parts. Mr. Gascoyon[1] records a case of this disease in which death by suffocation ensued.

The minute vein found lying along the parotid duct is a good guide to that structure, since it is constantly seen in dissection. The temporo-facial vein lies near the angle of the jaw and thus is of importance in studying the relations of the cervical lobule of the parotid gland.

The middle temporal vein is of relatively large calibre, and is in direct continuity with the supra-orbital vein. This circumstance, in connection with its method of termination through the temporal aponeurosis, renders it liable in inflammation of the eyelids, particularly of the upper lid, to become engorged. Hence the sensation of fulness about the brow in ophthalmia, and the indication for local depletion at the temple in some phases of this disease.

Billroth[2] describes an example of a congenital plexiform "neurofibromatous" tumor of the "upper eyelid and temple." The patient, a young man about eighteen years old, occupation that of a waiter, exhibited an obtuse swelling of the left temple, which extended thence to the upper eyelid, completely closing and distorting the palpebral fissure. When the lid was elevated by the hand, the vision was normal, and the motions of the ball were perfect. The swelling was not abruptly defined, but involved to a slight degree the fat of the orbit and of the temporal fossa. The morbid growth was associated with a small point of defective ossification in the left parietal bone. The tumor was successfully removed, and did not recur. Here, in a congenital growth extending along the course of the middle temporal vein (although this fact is not mentioned by the recorder), is an instance of an abnormal process depending for its interpretation upon a knowledge of anatomy.

The Internal Maxillary vein joins the main trunk of the temporal vein about midway between the zygomatic arch and the angle of the jaw. This vessel re-

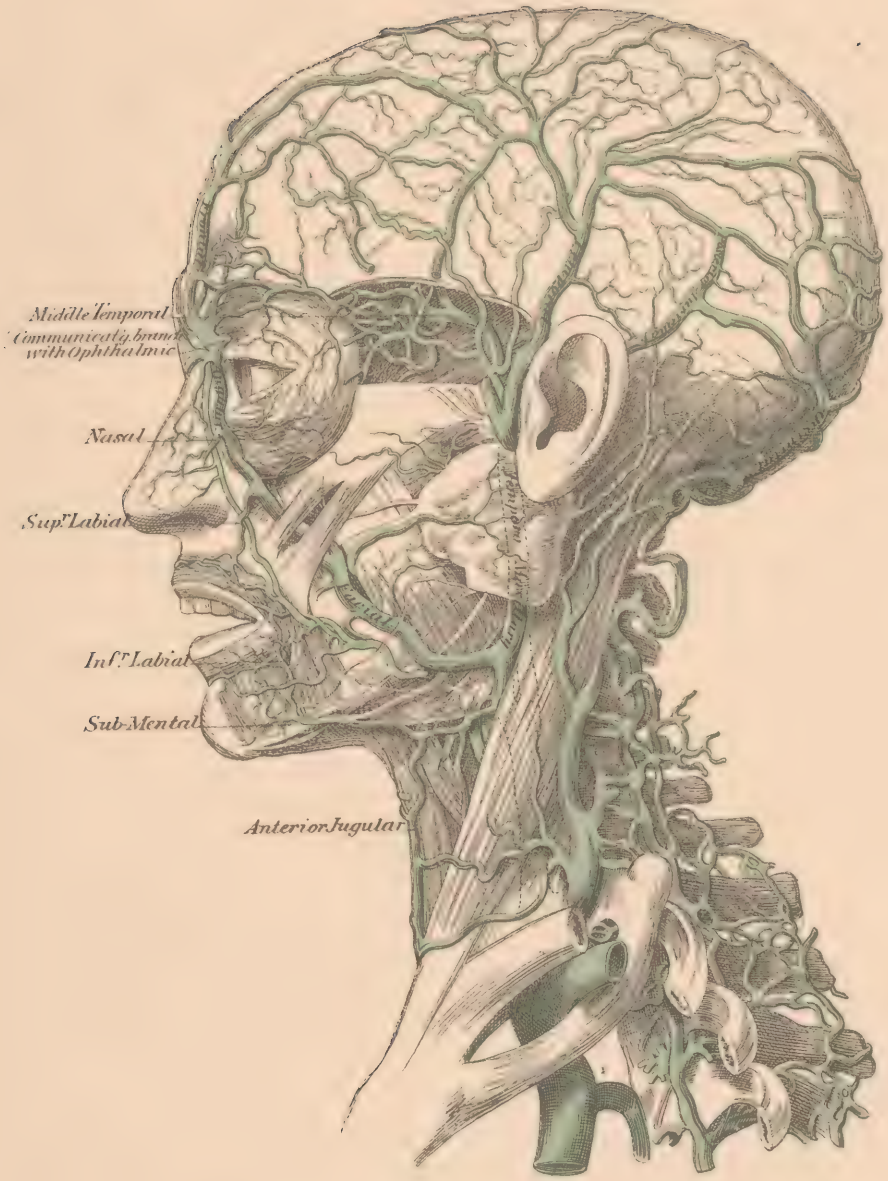
[1] Med.-Chir. Trans., xxiv. 1841, 36, fig.

[1] Trans. Path. Soc. Lond., xi. 1860, 267.

[2] Langenbeck's Archiv für klinische Chirurgie, 1869, 232.

EXPLANATION OF PLATE LXXI.

The external veins of the head and neck.



T. Sinclair & Son, Lith.

turns blood from the zygomatic and pterygoid regions, as well as from the deeper structures of the face and the interior of the brain-case. It corresponds in its general features to the internal maxillary artery, and receives branches in front from the infraorbital region, the nasal chamber and upper teeth, the inferior dental canal and the lower teeth, as well as from the Buccinator, Masseter, and Pterygoid muscles. From behind it receives the *deep temporal* branches of the deep veins of the temporal fossa, the *middle meningeal* vein from the interior of the brain-case, and the *deep auricular* vein from the external meatus.

The internal maxillary vein is remarkable for the formation of plexuses of small veins. One of these is situated at the anastomosis of the infraorbital with the facial vein; another lies in the pterygoid region. A similar arrangement of parts is seen about the inferior maxillary division of the fifth cranial nerve, from its point of escape at the oval foramen to its division into the lingual and inferior dental branches. The plexus last named joins the cavernous sinus through the oval foramen.

Variations.—The internal maxillary vein at times is received by the temporo-maxillary vein. The temporal and the internal maxillary veins may unite to form the temporo-maxillary vein, which is thus seen to be a different vessel from the temporo-maxillary as described by some English writers.

The meningeal branch and the trunk of the internal maxillary vein is an instance of survival of the large primitive jugular vein of the embryo, and the homologue of that permanent vessel in the lower animals, which is relied upon to convey the greater portion of the blood from the brain and its membranes to the veins of the neck. An explanation is thus offered of the otherwise exceptional fact that a vein, the greater part of which is derived from the face, receives a tributary from cranial structures so remote from it.

Remarks.—The lateral portion of the *pterygoid plexus* receives its blood from some tributaries of the internal maxillary artery, from the cheek, and from the veins about the neck of the inferior maxilla. The remaining portions receive branches from the deep temporal veins, as well as from the intracranial veins escaping from adjacent foramina. An extension of this plexus lies along the cartilaginous portion of the Eustachian tube, and anastomoses with the veins of the pharyngeal plexus. E. Zuckerkandl[1] believes that the pterygoid plexus of veins is capable of compressing the tube and considerably narrowing its lumen. The motion of the lower jaw, he believes, facilitates the act by which these veins become distended. It is probable that in this arrangement of parts an explanation can be found for the fact that the dulness of hearing, often found in edentulous persons, is remedied by the insertion of sets of artificial teeth.

[1] Monatschrift f. Ohrenheilkunde, x. 49. 1876.

The Temporal-Maxillary Vein (common facial) lies upon the neck, although for convenience it is retained among the veins of the head. It is formed by the union of the facial vein and the large communicating branch from the termination of the temporal. It extends downward and outward nearly in the line of the facial vein, and empties into the internal jugular vein.

The Posterior Auricular Vein arises behind the ear, where it anastomoses with the temporal vein in front and with the occipital vein behind. It joins the external jugular, and sometimes receives a communicating branch from the mastoid vein.

The Occipital Vein, as its name implies, is situated at the occiput. It descends obliquely outward and downward, accompanied by the occipital artery, to terminate in the internal jugular vein. Occasionally it ends in the external jugular. It anastomoses freely with the posterior auricular and temporal veins and with the vein of the opposite side.

The Lingual Vein arises from the side and base of the tongue. It often joins the facial, and through that vessel its blood reaches the internal jugular. As already mentioned, it may join with the pharyngeal, or with the external jugular vein. The tributaries of the lingual vein, seen in the living subject when the mouth is open and the tip of the tongue is elevated, are called *the sublingual veins.*

The Pharyngeal Vein derives its blood from the pharynx. It may open into the superior thyroid or lingual. The pharyngeal vein, carrying the return blood from the soft palate, lies along the course of the ascending pharyngeal artery. It receives some tributaries from the venules passing through the spinous and oval foramina, and empties into the external jugular at the lower end of the parotid gland.

II. The Encranial Veins.

The Encranial Veins include the following:—

I. Those of the Pia Mater.
II. Those of the Dura Mater (Sinuses).
III. Diploic and Meningeal Veins.
IV. Veins tributary to the Encranial Veins from Organs or Surfaces outside the Brain-Case.

I. THE VEINS OF THE PIA MATER.

The Veins of the Pia Mater. These constitute the first grouping of the trunks conveying the return blood from the brain. While the radicles are arranged in systems of coarse networks, the main vessels tend to accompany the cerebral arteries.

They are divided into four groups.

The *first group* is composed of the veins lying upon the upper and median surfaces of the cerebrum. They occupy the sulci for the most part, and are directed slightly forward toward their termination, where they join the great longitudinal sinus by seven or eight distinct trunks.

The *second group* is made up of veins derived from the interior of the brain. These collect blood from the choroid plexus and fornix, as well as from the walls of the lateral ventricle, and convey it to the velum interpositum, where the main vessels, called the *venæ Galeni*, or the *internal cerebral veins*, escape from the brain at the transverse fissure and empty into the straight sinus. As these vessels pass from the brain, they are inclosed in a tubular prolongation of the arachnoid, known as the foramen of Bichat. According to Luschka this foramen is best seen in the young. The veins from the crura cerebri enter the veins of Galen, each by a distinct trunk.

The *third group* includes the veins emptying into the sinuses at the base of the brain. These vessels are four in number. First, the *anterior cerebral vein*. This vessel collects blood from the supra-orbital convolutions, and joins the cavernous sinus. Second, *the middle cerebral vein*, which corresponds in position to the course of the middle cerebral artery, and is received into the cavernous sinus. Third, *the posterior cerebral vein*, which follows the course of the posterior cerebral artery, and empties into the lateral sinus. Fourth, *the anastomotic vein*. This consists of two branches, both passing forward from the posterior cerebral vein: one follows the course of the posterior cerebral artery; the other the external border of the spheno-temporal lobe, to join the middle cerebral vein in the Sylvian fissure. Duret describes them as emptying independently into the superior petrosal sinus. When the anastomotic veins empty independently of the middle cerebral, they constitute the *inferior cerebral veins*, which are specially described by Luschka. Two small veins from the spheno-temporal and occipital lobes empty into the superior petrosal sinus.

The *fourth group* comprises the cerebellar veins. The superior cerebellar veins, from two to four in number, extend along the upper surface of the superior vermiform process, and enter either the lateral sinus or the veins of Galen. The inferior cerebellar veins, smaller than the preceding, terminate in the same manner.[1]

II. THE VEINS OR SINUSES OF THE DURA MATER.

The Veins of the Dura Mater. These include the system of trunks lying betwen the layers of the dura mater. They connect the veins of the brain with those of the neck.

The Sinuses of the Dura Mater (fig. 2, Plate LXXII.; also Fig. 87) are sixteen in number:—

The Unpaired Sinuses.

- Superior Longitudinal.
- Inferior Longitudinal.
- Straight.
- Circular.
- Anterior Occipital.
- Posterior Occipital.

The Paired Sinuses.

- Cavernous.
- Spheno-Parietal.
- Superior Petrosal.
- Inferior Petrosal.
- Lateral.

The Superior Longitudinal Sinus extends from the *foramen cæcum* in the frontal bone to the internal occipital protuberance, where it ends in the torcular Herophili. It is narrow in front, wide behind, and of a triangular form. It at first lies upon the frontal crest, but afterward occupies the deepening groove upon the parietal and occipital bones. The interior of the sinus is traversed by numerous cords or trabeculæ. The superior and median cerebral veins join the sinus by branches which are directed forward, excepting a few at the anterior portion of the sinus, which, according to Cruveilhier, are directed from before backward.

Out of thirty subjects, P. Trolard[2] found in all but five a vein extending along the fissure of Sylvius between the superior longitudinal sinus and the superior petrosal sinus, or cavernous sinus. He designates this vessel as the great anastomotic vein.

The Inferior Longitudinal Sinus is lodged in the free inferior border of the falx, and collects blood from that membrane. It is small, of cylindrical form,

[1] For special studies of the veins of the pia mater, see P. Troland, Recherch. sur l'Anatomie du Système veineux de l'Encéphale et du Crane, 1868; also Archives Générales de Médecine, 1870, 257; also Ch. Labbé, Archives de Physiol. Norm. et Path., 2 série, t. vi. 1879, 135, fig.

[2] Archives Générales de Méd., March, 1870, 257.

and enters the beginning of the straight sinus above the veins of Galen. Unlike the superior sinus, it receives few or no collateral veins.

The Straight Sinus (sinus tentorii) is the continuation backward of the union of the inferior longitudinal sinus and the veins of Galen. It lies in the median line upon the upper portion or roof of the tentorium.

The straight and superior longitudinal sinuses unite in front of the internal occipital protuberance in the *torcular Herophili* (wine-press of Herophilus, confluens sinuum). This is a lacunal widening which communicates on either side with the lateral sinuses. Not infrequently the main current of blood is deflected either to the left or to the right of the median line, when the groove for the lateral sinus on the occipital bone corresponding to the line of greater deflection will be larger than the groove of the opposite side.

The Circular Sinus extends around the pituitary body and unites the two cavernous sinuses. It is often incomplete posteriorly, when the anterior connecting portion is called the transverse sinus.

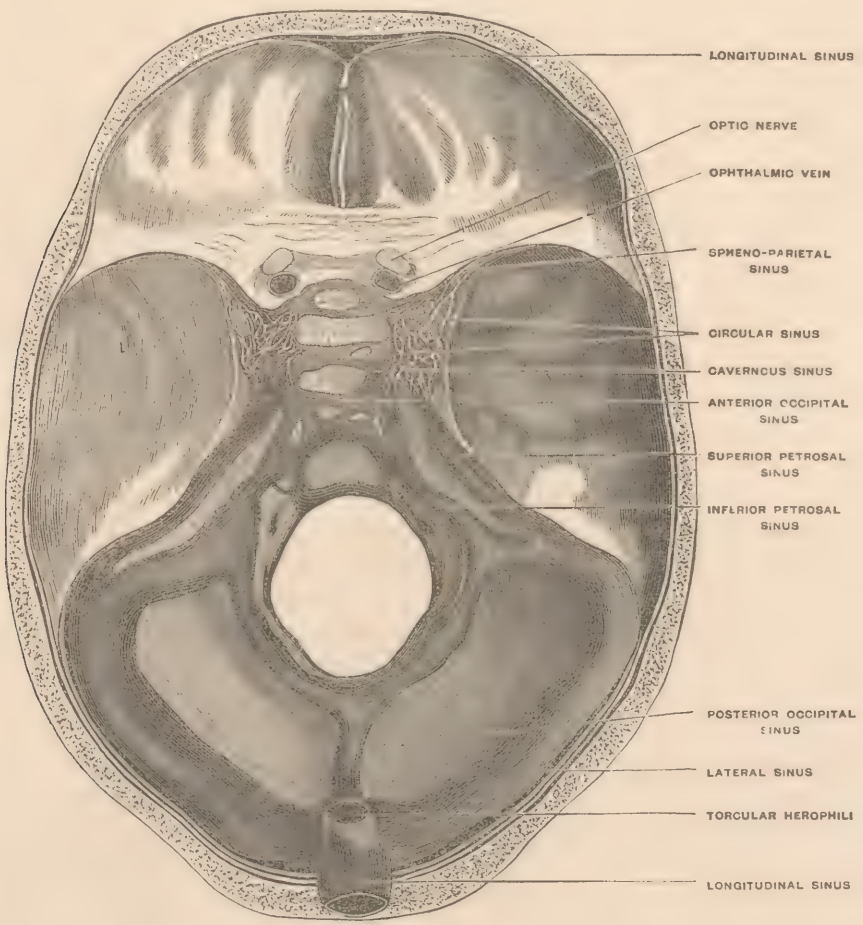
The Anterior Occipital Sinus lies in front of the foramen magnum, and unites the two inferior petrosal sinuses. It is very irregular, and, as a rule, small. A tendency to the exaggeration of the veins has led Virchow to include the sinuses in this position under the name of the basilar plexus. It represents upon the basilar process of the occipital bone the posterior vertebral veins of the vertebral column. These veins are apt to become enlarged in the aged.

The Posterior Occipital Sinus is formed by a small vein running around the posterior arch of the foramen magnum, and extending upward along the cerebellar falx. It anastomoses with the posterior spinal plexus. It also ascends along the cerebellab falx near its hinder border, and terminates at the *torcular Herophili.* The branch around the border of the foramen is sometimes mentioned as the *circular sinus of the foramen magnum.*

Under the name of the anterior confluent condyloid vein, Trolard[1] describes a vessel situated in front

[1] Loc. cit.

Fig. 87.



The Sinuses of the Dura Mater seen in Horizontal Section of the Skull.

of the anterior occipital condyle outside of the skull. As above remarked, this writer asserts that it receives from in front the inferior petrosal and the petro-occipital sinuses, as well as several small veins from the sides and from behind.

The Cavernous Sinuses are symmetrical structures lodged between the side of the body and the base of the great wing of the sphenoid bone. Each sinus presents an irregular outline, slightly tapering in front, where it receives the ophthalmic vein. It ends abruptly behind, where it joins the superior and inferior petrosal sinuses. It unites on its inner side with the circular sinus.

Among its minor points of limitation may be mentioned its extension a slight distance within the carotid canal at the side of the artery. This has received from Trolard the name of the *carotid sinus.*

Each cavernous sinus and the spheno-parietal sinus also receives one of the great meningeal veins of its own side. A small branch uniting the sinus with the pterygoid plexus passes through the oval foramen of the sphenoid bone. The interior of the cavernous sinus is traversed by fibrous bands, from which fact the sinus receives its name. Extending apparently through it, but separated from the venous blood by the delicate lining membrane, are the internal carotid artery and its plexus of filaments of the sympathetic nerve. The third, the fourth, and the ophthalmic division of the fifth pair run within the outer boundary of the sinus. A little to its outer side is the sixth pair of nerves.

The Spheno-Parietal Sinuses. These lie along the under surface of the lesser wing of the sphenoid bone. They communicate with the median meningeal vein with the anterior temporal and diploic, occasionally also with a small vein known as the ophthalmo-meningeal, and empty into the cavernous sinus.

The Superior Petrosal Sinuses are small, and extend on each side along the petrous bone on the ridge between the anterior and posterior surfaces. They lie between the layers of the lateral margin of the tentorium, and join the cavernous sinus to its inner, and the lateral sinus to its outer, side.

The Inferior Petrosal Sinus extends downward along the line of junction between the petrous and occipital bones. It joins the cavernous sinus in front and the lateral sinus behind. According to Trolard, *loc. cit.*, the inferior petrosal sinus does not join the lateral, but the anterior condyloid vein.

A small associated sinus is sometimes found lying below the preceding. It extends through the fibro-cartilage of the middle lacerated foramen. The petro-occipital sinus of Trolard extends from the anterior to the posterior lacerated foramen, and ends in the anterior occipital sinus.

The Lateral Sinuses extend between the *torcular Herophili* and the posterior lacerated foramen, where each sinus ends in the beginning of the internal jugular vein. Each lateral sinus is capacious, and lies in the transverse groove of the occipital bone, and in the deep sigmoid depression upon the mastoid portion of the temporal bone. The main current of blood within the lateral sinuses is carried directly to the internal jugular vein. They receive the blood from the superior and inferior petrosal sinuses, and very frequently from the cerebellar veins. Small posterior condyloid veins often empty into the lateral sinuses.

The right lateral sinus is commonly larger than the left. When the sinuses are symmetrical, the straight sinus commonly opens by two or three apertures on the anterior wall of the torcular Herophili.

III. THE DIPLOIC AND THE MENINGEAL VEINS.

The Diploic and Meningeal Veins are for the most part tributaries to the sinuses.

The veins of the diploë (fig. 1, Plate LXXII.) are received within bony canals, which traverse the diploë in an arborescent manner, and are directed from above downward. They are arranged, according to Breschet, in a frontal, a temporal, and an occipital set. They empty by piercing the inner plate of the skull and joining the sinuses of the dura mater, as is occasionally seen in the temporal set, which joins the sinus of the lesser sphenoidal wing. Those of the forehead join the ophthalmic vein. Those of the occiput terminate in the transverse or the occipital sinus. The diploic veins exist in great number as tortuous venous tracts of varying calibre, lined with pavement epithelium. Beginning without membranous walls, but gradually becoming better defined, they pass downward toward the lower limit of the vault of the skull. When the veins flow outward, they pierce the outer plate, and unite with the nearest vein of the scalp.

The meningeal veins proper, as distinguished from those already described, are the venæ comites of the corresponding arteries. The largest are the pair of veins of the great meningeal artery. One of these terminates in the cavernous sinus; the other escapes through the spinous or oval foramen, and joins the pterygoid plexus of the internal maxillary vein. Occa-

sionally a branch of the great meningeal vein empties into the cavernous sinus.

IV. VEINS TRIBUTARY TO THE ENCRANIAL VEINS FROM ORGANS OR SURFACES OUTSIDE THE BRAIN-CASE.

They embrace—

The Ophthalmic Veins.
The Venæ Emissariæ.

Numerous small veins not included in the above.

THE OPHTHALMIC VEINS.

The ophthalmic veins are two in number—

Superior Ophthalmic.
Inferior Ophthalmic.

The Superior Ophthalmic vein, or the ophthalmic vein distinctively so called, is an important trunk lying in the orbit. It receives tributaries from the frontal and facial veins, and within the orbit, from the eyeball and its muscles, from the ethmoidal cells and the lachrymal duct, as well as from the inferior ophthalmic vein. The main trunk answers in position to the ophthalmic artery, and, entering the brain-case at the median extremity of the anterior lacerated foramen, terminates in the cavernous sinus.

The Inferior Ophthalmic Vein lies at the base of the orbit, between the Rectus Inferior and the Rectus Externus muscles. After receiving tributaries from the facial vein and from the venules perforating the malar bone, it is joined by an anastomotic branch from the superior ophthalmic vein, and passes through the spheno-maxillary fissure, being then received by the pterygoid plexus. Occasionally it may empty with the superior ophthalmic vein into a common trunk which joins the cavernous sinus.

Remarks.—The superior ophthalmic vein is of special interest to the physician. It is the largest channel found in the adult by means of which blood from the head and face can enter the system of encranial sinuses. Inflammation of any of the veins of the face can thus involve by continuity the ophthalmic vein and the cavernous sinus (see Facial Vein, p. 417). Formerly the angular trunk of the facial was opened to relieve cerebral congestions. During facial contortions, the blood from the frontal and facial veins, being prevented from having free communication with the ophthalmic veins, is retained or conducted away by the anastomotic branches of these vessels with the superficial veins.

The superior ophthalmic vein, from its serving as a channel for the return of the blood from the eyeball, is to be carefully considered as a factor in many clinical intraocular conditions. Pressure in any part of the system of encranial sinuses, but more especially in pressure exerted at the anterior basal portion of the skull, creates turgescence in the retinal venules, conspicuous at the point of entrance of the optic nerve. Long-continued impact of swollen and indurated veins against the yielding fibres of the nerve is liable to impair their vitality, even after the venous blood returns to its accustomed channel and the turgescence disappears. The vein has been ruptured by severe blows, and the cellular interstices of the orbit found after death occupied by clot. The differential diagnosis between the varieties of venous hemorrhage, as occurring either from a ruptured ophthalmic vein following a blow without fracture of the base of the skull, or from a blow with fracture of the base of the skull, is difficult to establish. While subconjunctival ecchymosis is present in both forms of the lesion, cerebral congestion, inflammation, and coma are absent in the first named, but likely to be present in the last.

The inferior ophthalmic vein pursues a course that might have been anticipated, when the fact is recalled that in the lower animals the orbit, temporal, and zygomatic fossæ are not separated from one another. In studying the course of this vein it is shown that a communication with the encranial blood is possible by means of the pterygoid plexus, which receives meningeal veins as tributaries. Such connections, however, are not known to have practical import.

Venæ Emissariæ.—A number of small veins termed the venæ emissariæ, and not enumerated among the diploic veins, reach the sinuses either from outside the skull or from the middle and the inner ear.

Among those which enter the sinuses from without may be mentioned the mastoid vein, which reaches the lateral sinus through the mastoid foramen. This is ordinarily small, but may attain the diameter of a goose-quill.

F. Bustard[1] narrates a case in which, after suppuration of the mastoid cells, the pus escaped from the cells through the mastoid foramen.

The veins passing from the ear are unimportant. They may be enumerated as follows: The *tympanic vein*, which runs through the junction of the petrous bone with the squama, and joins the superior petrosal sinus. The *vein from the vestibule*, which escapes through the *aquæductus vestibuli*, and joins the same sinus. The *internal auditory veins*, which escape from the internal auditory meatus, and unite with the inferior petrosal sinus. The *posterior condyloid vein*

[1] Br. Med. Journ., 1871, 89.

which joins the lateral sinus. The relation which these veins bear to those about the foramen magnum is worthy of mention. Luschka has pointed out that it is possible for the veins surrounding the anterior condyloid foramen to press upon the hypoglossal nerve.

Remarks on the Encranial Veins.—The veins of the brain and its membranes have varying relations to the arteries. With the exception of the larger veins of the pia mater, no set of veins accompanying the arteries can be said to exist.

The tendency is for all the encranial venous blood to be collected at the base of the brain, and thence to flow backward and escape from the head at the posterior lacerated foramen at the commencements of the internal jugular veins. Many less important points of exit exist, such as the foramen magnum, where the basilar vein and the circlet of veins about the foramen magnum join the vertebral or the posterior pharyngeal veins; the spinous foramen; the various small foramina at the base of the skull, without distinctive names; and numerous irregular openings at the side of the skull about the squama, or near the lines of union of the squama with the adjacent bones. In addition to these, it is seen that the blood from some of the radicles of the ophthalmic vein is conducted away from the orbit by means of the veins accompanying the internal maxillary artery.

The blood of the anterior and middle portions of the skull contents tends to empty into the cavernous sinuses; that of the posterior portion—including the posterior lobes of the cerebrum, the cerebellum, and the cerebral peduncles—into the lateral sinuses. Free anastomoses occur between the two great sets.

Luschka describes the opening defined by the anterior border of the tentorium and the base of the skull as the *incisura tentorii* or the superior occipital foramen, and suggests that it may, under some conditions, exert pressure upon the return flow of blood from the middle of the cerebrum, and thereby induce dropsical effusion in the ventricles in the same manner that pressure on the portal vein may induce ascites.

In the aged the sinuses tend to enlarge, and the spaces about the Pacchionian bodies to widen, as they contribute to form the meningeal veins or the branches which join the superior longitudinal sinus. At the base of the skull, the lateral sinuses, and the internal jugular veins at their origins in the same class of subjects, are apt to be dilated, and the entire system of veins around the basilar process of the occipital bone and atlo-occipital articulation to be in like manner enlarged.

Relief from encranial venous pressure may be effected by the blood finding exit from the skull as follows: In the occipital region, through the internal jugular vein and the mastoid vein; in the frontal region, through the ophthalmic vein, and the vein in the foramen ovale; at the basal region, through the petrosal sinuses and the posterior condyloid vein; and at the vertex, through the diploic vein and the minute veins penetrating the outer table of the skull to join those of the scalp.

The anastomotic branches between the two internal carotid arteries and the branches of the basilar artery having been noted, it is of interest to detect an anastomotic trunk uniting the middle cerebral with the posterior cerebral vein, which thus permits the passage of venous blood by means of the anterior basilar vein into the sinuses about the foramen magnum.

From the above statements it is evident that it is possible for the venous blood to escape from the brain by other channels than the internal jugular veins. It the occlusion of these main channels were slowly affected, the veins at the back of the pharynx and the beginning of the vertebral canal, together with the internal maxillary veins, could relieve the contents of the orbit, together with the anterior portion of the cerebrum, of much of their superfluous blood.

The *cavernous sinus* may be secondarily involved by extension of inflammation along the line of the ophthalmic vein. Such involvement is of grave import, since it is soon followed by stasis in the anterior and middle cerebral veins emptying into the sinus. If the communication of the middle cerebral vein with the petrosal sinuses, or the anastomosis of the middle cerebral with the posterior cerebral vein, be not sufficient to deflect the cerebral venous blood to the internal jugular vein, the cerebral stasis soon ends in inflamma-

EXPLANATION OF PLATE LXXII.

Fig. 1. Veins of diploë.

Fig. 2. Sinuses of the dura mater seen in a sagittal section of the skull.

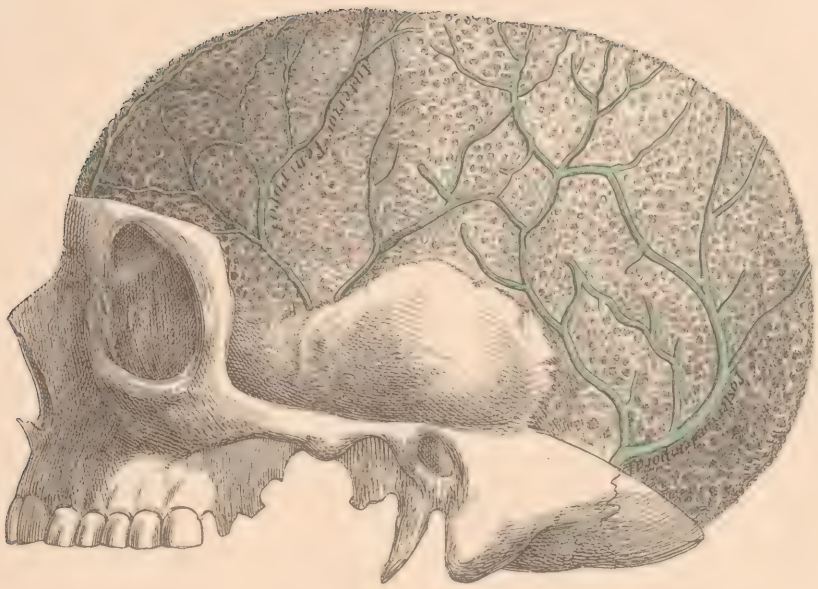


Fig. 1.

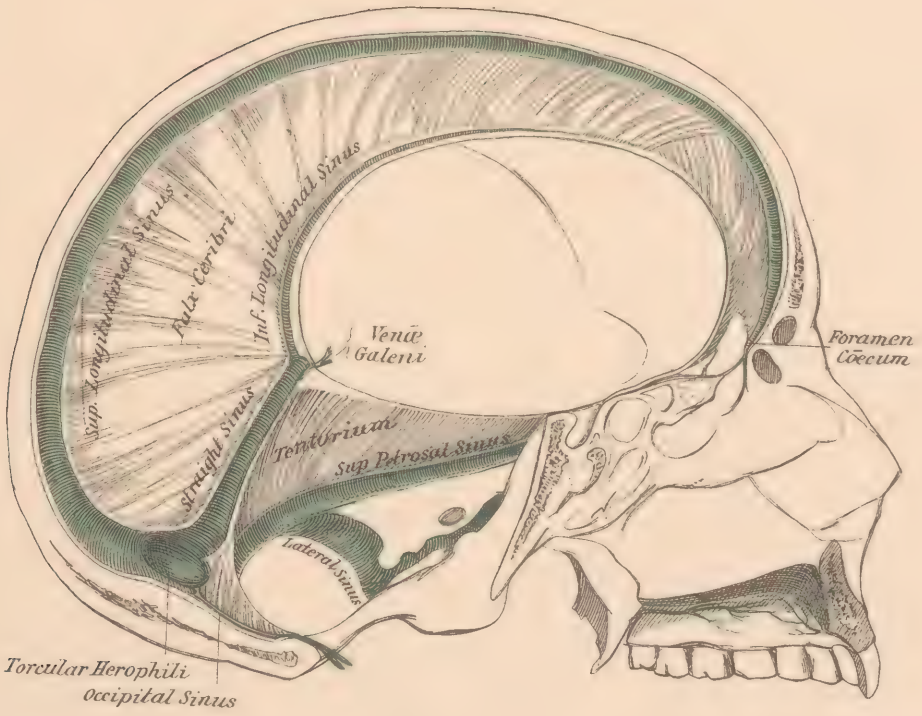


Fig. 2.

T. Sinclair & Son, Lith.

tion, and death ensues. Erysipelas of the face, facial carbuncle, necrosis of the superior maxilla,[1] syphilitic ozœna,[2] and traumatic lesions of the face, orbit and nasal chambers may thus prove fatal.

Basic pressure of any kind may induce stasis in the cavernous sinus, one of the most noticeable of the effects of which is venous congestion of the orbital contents. The ophthalmoscope under such conditions detects congestion of the retina and infiltrations in and about the point of entrance of the optic nerve (optic disk). The condition of the cavernous sinus and of the cerebral membranes can in this way be determined during life.

A clot in the cavernous sinus will of course be apt to press against the nerves passing through or in the walls of the sinus, and paralysis of the parts supplied by one or more of them may ensue. It is stated, on the authority of Seseman[3] that compression of the cavernous sinus is not followed by any considerable venous stasis of the retina as long as the anastomosis of the facial with the ophthalmic vein remains permeable.

The *inferior petrosal sinus* may be looked upon as an important anastomotic sinus between the posterior and the anterior tract of the venous return.

The *longitudinal sinus* may be the seat of inflammation[4] and embolus.[5] From the fact that the depressions in the skull corresponding to the sites of the Pacchionian bodies may be in intimate relation with the walls of the sinus, great care is enjoined upon surgeons to avoid the median line in all operations upon the skull-cap. A case[6] came under the observation of Dr. Wm. Hunt, of Philadelphia, in which, consequent upon fracture of the vertex of the skull, a spicule of bone had perforated the longitudinal sinus. Upon elevating the fragment of skull from which the spicule projected, an enormous quantity of venous blood welled from the wound. The hemorrhage after some difficulty was checked by suturing the edges of the dura mater on either side of the wound, and by the careful adjustment of compresses. The patient lived a fortnight, when he died of the general effects of fracture of the skull.

The *lateral sinuses*, receiving as they do important tributaries from the longitudinal and inferior petrosal sinuses, are capable, when diseased, of involving the entire encephalic circulation. The most direct flow into them is that of the blood derived from the posterior lobes of the cerebrum and from the cerebellum. Inflammation of this sinus is of more frequent occurrence than in any of the sinuses of the dura mater. Its most frequent cause is inflammation and necrosis of the mastoid portion of the temporal bone (*q. v.*) in children. Fracture of the base of the skull may extend into the lateral sinus — the blood escaping outward into the chamber of the tympanum, and thence by rupture of the tympanic membrane into the external meatus, or inward by the Eustachian tube to the pharynx. According to Prescott Hewett,[1] the latter event may take place even when there is a rupture of the tympanic membrane. In connection with this, Mr. Hewett uses the following language: "A discoloration of the integument of the lateral parts of the neck appearing subsequent to an injury of the head may serve as a guide to the diagnosis of a fracture of the base. The blood oozing from the fractured skull gradually infiltrates the cellular tissue of the neck, and thus ultimately reaches the skin, which becomes discolored, as if bruised. And a sudden puffiness in the occipital region, with discoloration of the skin, some hours after a severe injury of this part of the head, may also be of use in the diagnosis of fracture at the base. The large venous sinuses connected with the occipital bone may be torn across in such a lesion, and thus give rise to an extravasation of blood, which, gradually oozing through the line of fracture, may ultimately show itself in the superficial parts, and thus reveal the nature of the injury."

Hemorrhage may occur from both the petrosal and lateral sinuses, as a result of caries of the temporal bone. Cases of rupture of the lateral sinus unaccompanied by fracture have been reported.[2] As much as ten ounces of blood may escape through a lesion of this character.

Fracture of the skull accompanied by depression over the region of the lateral sinuses has been known to end fatally by hemorrhage consequent upon attempts to raise the fragments into position.

II. The Veins of the Neck.

The Veins of the Neck are—

External Jugular.
Anterior Jugular.
Internal Jugular.
Vertebral.[3]

[1] A. Poland, Med. Times and Gaz., 1869, 383.
[2] H. Weber, Med.-Chir. Trans., xliii. 177.
[3] Archiv für Ophthal., xii.
[4] Hammond, Diseases of the Nervous System.
[5] Delafield's Pathological Anatomy, 44.
[6] Unrecorded.

[1] Holmes's Syst. of Surg., vol. ii. 129, ed. 1861.
[2] Surgery, Sir Chas. Bell. See also Lond. Med. Gaz., iv. N. S., 1847, 31.
[3] Described on p. 415.

The External Jugular Vein arises from the temporal vein at the lower part of the parotid region, and at once receives an important accession from the posterior auricular vein. The vein passes perpendicularly down the neck, crossing the Sterno-Cleido-Mastoideus muscle, pierces the deep fascia at the base of the neck to the outer side of the muscle, and ends in the subclavian vein, a short distance from the internal jugular. Sometimes it joins the latter vessel, or it may enter at the point of junction of the two vessels. When the external jugular is duplicate the more deeply seated trunk receives the name of the posterior external jugular vein.[1]

A valve is usually found at the mouth of the main vein. Two inconstant veins join the outer side of the external jugular near its mouth, namely, the *transversalis colli* and the *suprascapular* veins.

In fœtal life the blood escapes from the brain-case between the tympanic bone and the squama in front. This arrangement persists in some quadrupeds, such as the dog and some ruminants. According to Luschka,[2] there is found at times in the adult a distinct vein passing out through the petroso-squamosal suture.

Remarks.—The external jugular vein was formerly selected for phlebotomy in cervical and facial congestions. Hoffman[3] reports a case of fatal concealed hemorrhage arising from the external jugular vein in a child of five years who after scarlet fever suffered from a cervical abscess.

Variations.—The intimate relation existing between the anterior extremity and the structures of the neck, so often suggested by the arrangements of the muscles, nerves, and arteries of the shoulder, is further sustained by occasional peculiar dispositions of the external jugular vein. This vessel may receive the cephalic veins either above or below the clavicle; or the external jugular vein may pass over the clavicle and empty into the subclavian vein. It may receive a branch passing upward from the skin over the Pectoralis Major. As already noted, the mastoid vein sometimes joins the external jugular, and at other times it joins the occipital vein.

The Anterior Jugular Vein is very inconstant. As a rule it is formed by radicles from the supra-hyoid space, and by anastomotic branches from the facial and external jugular veins. It passes down the neck in front of the larynx and trachea a little to the outer side of the median line. It lies parallel to the vein of the same name on the opposite side of the neck, being connected with it by a *transverse vein*[1] (transverse branch, great transverse vein); hence the name anterior jugular plexus sometimes given to the pre-laryngeal and pre-tracheal veins. Passing outward at the base of the neck, behind the Sterno-Cleido-Mastoideus muscle, the anterior jugular vein empties either into the external jugular or into the subclavian vein. When the transversalis colli and the suprascapular veins do not join the external jugular, they are, as a rule, tributary to the anterior jugular vein.

The communication of the anterior jugular with the facial veins is rare in man, but is the rule in mammals. Rathke shows that the facial vein receives the lingual in mammals.[2] The normal junction, in man, of the ranine vein with the facial, is suggestive of the close relations which exist between the facial and the lingual veins.

In the region of those veins usually uniting to form the anterior jugular, is occasionally found extending deep in the median line a *superficial median jugular vein.* Above, it receives the superior thyroid veins at the upper border of the isthmus, taking the place of the usual small trunk; and below, the inferior thyroid veins; finally, it empties into the transverse vein. It is not of necessity a compensative trunk for the superficial anterior jugular vein; for the two may be present together.[3] The remaining veins of the neck lie beneath the deep fascia.

The *variations* of the anterior jugular vein are numerous. The two veins may not unite at any point below the hyoid bone; they may unite at the base of the neck in a single trunk. They may be represented by a single vein extending along the median line. The two veins may be united at the base of the neck by a transverse vein.

The trunks, while normally disposed, may not lie in front of the larynx and trachea so much as at the side, and may, indeed, lie within the depression in advance of the Sterno-Cleido-Mastoideus muscle. The vein may be formed by the union of the facial and temporal veins, the trunk subsequently dividing into two branches over the clavicle, the one emptying into the subclavian vein, and the other into the external scapular.[4]

[1] W. Gruber, Virchow's Archiv, Bd. 54, 1872, 188.

[2] Zeit. für rationale Medecin, 1859.

[3] Lond. and Edin. Month. Journ. Med. Sci., 1844, 632.

[1] This *transverse vein* should not be confounded with the transverse vein uniting the primitive jugular veins in the embryo (see p. 412). To distinguish between them the latter might be called the *fœtal transverse vein.* The older English writers sometimes call the subclavian veins *the transverse veins.*

[2] For an admirable representation of the veins of the neck in the rabbit see Paul Schneider, Topog. Anat. des Vorderhals beim Kaninchen, etc. Berlin, 1868, Taf. 1.

[3] Dr. L. S. Pilcher, Annals of Anat. and Surgery, 1881, 158.

[4] W. Gruber, Virchow's Archiv, Bd. 54, 1872, 188.

The *superior thyroid* vein is in association with the artery of the same name. Below it is placed a smaller vein called the *middle thyroid.* The great vascularity of the thyroid body determines a number of venous trunks in and about it, which tend to follow the course of the arteries of the same region. The veins passing upward from the thyroid body may be considered as tributaries to the superior thyroid vein, and those passing downward as tributaries to the inferior thyroid. The superior thyroid veins proper are two in number, one on each side of the superior thyroid artery. Answering to the anastomosis of the superior thyroid arteries, at the upper border of the isthmus of the thyroid body, is a *transverse* vein which connects the two superior thyroid veins. Lying in the pretracheal space, extending thence to the left innominate vein, and in a sense parallel to the inferior thyroid artery, is the *inferior thyroid* vein. This vein is often independent of a second inferior thyroid vein which joins the internal jugular at or near the level of the inferior border of the thyroid body.

Remarks.—For the entrance of air into veins, see Internal Jugular Vein.

An incision across the inferior thyroid vein, whose walls, being imbedded in inflamed tissue, could not collapse, has caused sudden death by the entrance of air. Parise,[1] in attempting to seize the divided inferior thyroid vein during tracheotomy, lifted the superficial wall only, thus permitting air to enter the vein with a fatal result.

In connection with this it may be said that incisions in the neighborhood of the large veins of the neck should always be made upon the director, and, before dividing a large vein, two ligatures should be applied, the division being made between them.—All the superficial veins of the neck become distended in prolonged expiration, or when breathing is suspended. In the acts of singing and coughing they are especially prominent.

The Internal Jugular Vein. This important vessel extends from the jugular foramen to the base of the neck, where it joins the subclavian vein, the two uniting to form the innominate vein. As the largest vein of the neck, it receives by far the greater portion of the venous blood of the head. It inclines slightly forward and downward toward the median line, and, as it descends, becomes more superficial. The vein is abruptly swollen at its origin to constitute the *bulb* or *gulf*, and remains about the same size until it reaches a point opposite the larynx, when it attains its greatest width after the reception of the veins from the face and the pharynx. It is slightly contracted just before it empties into the innominate vein, and is provided at this point, as a rule, with a double valve, which is situated upon its outer wall.

The *relations* of the vein are as follows: At its upper part, it lies to the outer side of the Rectus Capitis Lateralis muscle, behind or close to the outer side of the internal carotid artery. Along the common carotid artery, the vein lies to the outer side, the pneumogastric nerve lying between them. Behind the vessel, at the base of the neck, lies the thyroid axis. The vein receives the pharyngeal, the common facial, the superior thyroid, the occipital, and often the lingual veins.

Variations.—The internal jugular vein receives some inconstant branches at its origin. Thus the inferior petrosal sinus sometimes ends in this vessel instead of in the lateral sinus. The premature closure of the suture between the occipital and temporal bones may determine the absence of the internal jugular vein of that side. C. Weigert[1] dissected a subject which presented the above-named anomaly.

Remarks.—For clinical purposes the internal jugular vein is conveniently divided into two portions: the one, extending from the base of the skull to the level of the larynx; the other, extending from the level of the larynx to the termination of the vein.—The fact that all large veins are of diminished calibre during inspiration, and of increased calibre during expiration, is worthy of more than a passing notice in connection with the internal jugular, since this is the largest of the superficial veins of the body. During expiration the vessel may be said to overlap the common carotid artery, and is conspicuously seen in the course of the more important operations upon the neck. But during inspiration, the walls of the vessel recede from the surface, and are in less danger of being lacerated or cut. In marked effusion into the pleural sac, the veins of the neck on the corresponding side are, according to Sibson,[2] swollen even during inspiration. The danger of sudden death from a wound of the vessel is imminent, since air may be drawn within the vein and carried to the heart, and, by means of the pulmonary artery, to the lungs. A wound at the basal third of the neck is more dangerous than one at any other point, from the fact that the lips tend to remain apart during inspiration.—The

[1] Archives Générales de Médecine, 1880, 571.

[1] Virchow's Archiv, Bd. 84, 184; also Mr. Chien, Journ. of Anat. and Phys., ii. 222.

[2] Medical Anatomy, col. 12.

internal jugular vein, notwithstanding its size, is rarely wounded. It has been opened during the extirpation of a bronchocele, but without fatal issue;[1] and in one instance it has been punctured by a fragment of fractured clavicle.[2]—It has frequently suffered from the effects of ulceration in its coats. When suppuration has followed a high grade of cellulitis near swollen lymphatic glands, such as are so common in scarlet fever, the danger of ulceration of the walls of the internal jugular vein is universally conceded.[3]

Cervical sinuses resulting upon degeneration of the lymphatic glands will, in rare instances, involve the coats of the vein. In a case of this character, reported by Dr. D. W. Cheever,[4] the repeated escape of blood of a cranberry hue, from a sinus, led the observer to conclude that the common carotid artery was ulcerated. The vessel was tied, but the hemorrhage recurred and proved fatal. At the autopsy, the walls of the vein were found ulcerated through, while those of the artery were intact.

The vein may be occluded by pressure from without, as by an enlarged lymphatic gland,[5] or by an encephaloid tumor of the thyroid body, which may compel the blood from the corresponding side of the head to pass by a transverse vein to the internal jugular of the opposite side.[6] Various other cancerous growths of the neck may impinge upon the vessel, or the vein may be impervious without apparent cause. L. S. Pilcher[7] found the right internal jugular vein impervious from the base of the skull to within a short distance of the innominate vein. The median veins were abnormally large.

The internal jugular vein may be inflamed from its escape at the base of the skull to the orifice of the inferior thyroid veins, and be occupied by black detritus of clot. It may also be secondarily involved by malignant disease.[8]

The Veins of the Upper Extremity.

The veins of the upper extremity are of two sets: the *superficial* and the *deep*.

The *superficial veins* are subcutaneous. They are numerous and inconstant about the hand, but are fewer in number and more regular in distribution in the forearm and the arm. The veins are better developed upon the back of the fingers and hand than on the palm; and better upon the front of the forearm than on the back. The veins on the back of the hand are collected chiefly from the sides of the fingers, where they lie behind the digital arteries. The vein on the ulnar margin of the little finger passes upward along the corresponding border of the fifth metacarpal bone. The other veins seen upon the dorsum answer in position to the second, third, and fourth interosseous spaces. The external vein of the index finger, and the two marginal veins of the thumb, unite to form a small trunk called the *main vein of the thumb*. It communicates with the veins of the palm through the opening for the radial artery in the first interosseous space.

The *radial* vein extends along the ulnar margin of the Supinator Longus to the elbow, and terminates in the *cephalic vein*, which continues its upward course to the outer side of the Biceps muscle to gain the groove between the Deltoid muscle and the Pectoralis Major. The vein, after piercing the coraco-brachial fascia, terminates in the axillary vein. A branch of the vein may pass in front of the clavicle.

The *ulnar* vein extends upward parallel to the ulnar border of the forearm to the elbow; a branch, often called the *posterior ulnar*, ascends upon the posterior surface of the forearm near the ulnar border to join the main trunk near the elbow. It is continuous above with the *basilic* vein, which is larger than its fellow, the cephalic, but ends at a much lower point, viz., about midway along the inner border of the Biceps, where it passes through a slit-like opening to join one of the venæ comites of the brachial artery. The basilic vein is more constant in position than the cephalic, and lies in front of the brachial artery.

The *median* vein, the least constant of the veins of the upper extremity, is placed in the forearm between the radial and ulnar, and lies upon the Palmaris Longus. It terminates, as a rule, below the bend of the elbow by dividing into two small veins which diverge: the inner (lying over the fibrous prolongation of the tendon of the Biceps) goes to join the basilic vein; the outer the cephalic. These are called the *median basilic* and *median cephalic* veins respectively. Filaments of the cutaneous nerves are seen in relation with these two trunks: the anterior branch of the internal cutaneous nerve passes either behind or in front of the median basilic.

At the point of division into these trunks, the median vein sends a deep branch to join one of the venæ comites of the ulnar or radial arteries.

[1] W. W. Greene, Amer. Journ. Med. Sci., Jan. 1871, 80.
[2] J. W. Ogle, Br. Med. Journ., 1873, 83.
[3] S. W. Gross, Amer. Journ. Med. Sci., 1871, 337. Literature.
[4] Archives of Clinical Surgery, ii. 1877, 127.
[5] J. F. Metcalfe, N. Y. Journ. of Medicine, 1850, 37.
[6] Burns's Surg. Anat. of the Neck, 236.
[7] Annals of Anatomy and Surgery, 1881, 159.
[8] See p. 338.

Variations.—Sometimes the median vein will consist of three branches. The venæ comites may unite to form a single vessel which passes between the two roots of the median nerve to join the axillary vein.

The veins on the back of the forearm are constant for the most part, and increase the volume of the ulnar vein. A central trunk, more constant than the others, is called the *interosseous vein.*

The radial may carry most of its blood to the basilar by a large radio-basilar vein, which also receives the greater part of the blood from the median.

The *deep veins* consist for the most part of the venæ comites of the main arteries of the limb; they possess more valves, and are less variable, than those of the superficial set. The superficial contribute to the volume of the deep veins, especially in the neighborhood of joints.

The deep veins terminate through the venæ comites of the brachial artery, emptying into the axillary veins at the lower margin of the Subscapularis muscle. According to Cruveilhier, the circumflex vein does not join the axillary directly, but runs for some distance parallel to its course.

Remarks.—The median basilic vein is the one usually selected for phlebotomy. For the effects of phlebitis, see Axillary Vein.

THE AXILLARY VEIN.

The Axillary Vein extends from the tendon of the Latissimus Dorsi muscle to the upper border of the Pectoralis Minor at the lower edge of the first rib. It terminates in the subclavian, with which it is continuous. It lies to the inner side of the axillary artery, the ulnar nerve and the inner head of the median nerve alone intervening. In front of its upper portion is the Pectoralis Minor muscle.

The vessel receives veins accompanying the branches of the axillary artery, as well as the basilic and cephalic veins. In rare instances it is double. Not uncommonly the trunk is single and well defined in the parts answering to the first and second portions of the artery of the same name; while opposite the third portion of the axillary artery its place is taken by two trunks, the outer of these receiving blood from the venæ comites of the brachial, and the inner from the skin of the inner side of the arm and the chest wall.

Remarks.—The axillary vein is sometimes ruptured by the fragments of a broken humerus. This occurred in an instance reported by Fraser,[1] in a boy thirteen years old. Ligation was performed, and the patient recovered.—B. Cooper[2] details the serious effects of air entering this vein during an amputation at the shoulder-joint. The patient, after a protracted illness, recovered.

The axillary vein is the point at which the changes peculiar to phlebitis of the superior extremity are arrested. This arrest is in harmony with the fact that an inflammatory process in one vein is not liable to be continued into the trunk into which it empties, provided that the trunk is of much greater lumen than its tributary. Any of the radicles of the veins of the hand, the forearm, and the arm, readily transmit the effects of inflammation, since their calibres are nearly equal; but inflamed venous tracks, as they join the axillary vein, have but little disposition to involve that vein. As far as the writer knows, the effects of phlebitis of the superior extremity are rarely transmitted to the subclavian vein, and never thence either to the internal jugular vein or the innominate vein. This limitation to the spread of inflammation of the veins in the upper extremity is in marked contrast to the tendency of femoral phlebitis, which frequently involves the iliac vessels, and may even invade the inferior vena cava. The position of the axillary vein, being as it is in a region of comparative security and rest as compared with that of the femoral vein, may explain this contrast.—Phlebitis of the axillary vein, and inflammation of the axillary lymphatic glands and vessels, when of high grade, are apt to involve the upper intercostal spaces and the parietal layer of the pleura. In this way a fatal pleurisy may supervene upon a phlebitis and an angeioleucitis.

THE SUBCLAVIAN VEIN.

The Subclavian Vein is less arched than the artery which it accompanies, and extends from the lower margin of the first rib to the sterno-clavicular articulation. It rests upon the first rib, which it crosses obliquely from below upward and inward to reach the inner side of the subclavian artery, from which it is separated by the Scalenus Anticus muscle. As its name implies, it lies beneath the clavicle, as well as beneath the costo-coracoid fascia, the Subclavius muscle, and the clavicular fibres of the Pectoralis Major muscle. Toward its termination it may be

[1] Lancet, 1849, 205.

[2] Med. Chir. Trans., xxvii., 1844, 41.

apparent just above the line of the sterno-clavicular articulation, when it will be covered by the origin of the Sterno-Cleido-Mastoid muscle.

The subclavian receives veins answering to the branches of the subclavian artery, the most constant of these being the transverse scapular vein.

The *variations* of the subclavian vein present some unusual features. Thus, very rarely, the vein and artery are interchanged in position, the vein passing behind the Scalenus Anticus, while the artery lies in front of it. Or the vein lies with the artery behind the muscle. An equally rare occurrence is for the vein to be double. Luschka describes a specimen in which there was a single vein which divided at the Scalenus Anticus muscle, embraced that structure, and reunited to its median side.

Remarks.—Toward its termination the anterior wall of the vein is fixed by the superficial fascia. Beneath the clavicle, in the angle which is formed between the Subclavius muscle and the first rib, the vein is in intimate association with the fascia of this muscle. It follows that in movements of the clavicle, a corresponding motion is transmitted to the anterior wall of the vein.

In elevation of the clavicle, as in forced inhalation, the return flow of blood from the upper extremities is in this way facilitated. Henle lays especial stress upon the above arrangement in reference to operative procedures about the shoulder, since elevation of the clavicle may lead to entrance of air into the subclavian vein.—The vein may be obstructed at the junction with the internal jugular vein. The orifices of the thoracic ducts are as a consequence compressed. For compression of the subclavian vein by the clavicle, see p. 169.

THE AZYGOS VEINS.

The Azygos Veins (figs. 2 and 3, Plate LXI.) are representations of the cardinal veins of the fœtus. They are two in number, the right or great azygos, and the left or hemiazygos.

The *Right Azygos Vein* (vena azygos major) is the larger of the two. Arising from the radicles of the lumbar and at times of the renal veins, it may receive a branch from the inferior vena cava. It ascends vertically, passing into the thoracic cavity through an interval between the fibres of the right crus, or through the aortic opening of the Diaphragm. It is received within the posterior mediastinum, and lies to the right side of the thoracic duct, behind the root of the right lung, above which it turns forward over the right bronchus to empty into the superior vena cava from behind, just above the pericardium.

The vein receives directly the *right* intercostal veins, excepting the first and second, which unite before joining the third intercostal vein. The vein conveying blood from the seven upper intercostal spaces of the *left* side (left superior intercostal vein) joins the right vein opposite the sixth or seventh dorsal vertebra. It is noteworthy that the intercostal veins of both sides have free communication with the innominate veins.

The right azygos vein also receives blood from the trachea, bronchial tubes, œsophagus, posterior mediastinum, and from the thoracic walls at the fifth and sixth left intercostal spaces. It sometimes anastomoses with the inferior vena cava, at times with the right primitive iliac vein, or with the lumbar as well as with the two innominate veins. Its valves are but few.

The *Left Azygos Vein* (hemiazygos, vena azygos minor) may be considered as a tributary to the right or main vein. It collects blood from the left lumbar and renal veins, and commonly receives a branch from the left iliac. After entering the thorax either through the aortic opening or the left crus of the Diaphragm, the vein crosses the vertebral column obliquely at the seventh or eighth dorsal vertebra, behind the aorta, and joins the right vein at an acute angle. While the hemiazygos vein commonly joins the azygos at the level of the ninth or the tenth dorsal vertebra, it may have a range from the sixth to the eleventh.

The *variations* of the azygos veins are numerous. Thus the right may open into the vena cava higher than as above described, and may even be received within the right innominate vein. In rare cases the vein may join the cava within the pericardium, or enter the right auricle of the heart. At times the left vein unites with the superior vena cava instead of with the right vein, or it may join the left superior intercostal trunk of its own side. The latter vein may not empty into the right veins, but may pass directly into the left innominate vein. The left azygos may send an accessory vein downward over the front of the left kidney and the Psoas Magnus muscle of the same side, to join the left common iliac. For further discussion of the azygos veins, see "Remarks" under Inferior Vena Cava.

J. Chienne[1] describes a case of anomalous distribution of the azygos vein which was associated with the presence of a supernumerary lobe of the right lung.

[1] Journ. of Anat. and Phys., iv. 89, 1870.

THE SPINAL VEINS.

The Spinal Veins are arranged in three groups: one upon the posterior surface of the vertebral column, the others within the vertebral canal. The first group consists of the *dorso-spinal* veins or dorsal plexus; the second group, of the *anterior* and *posterior longitudinal spinal* veins and the *veins of the spinal cord.* The spinal veins are remarkable for their plexiform arrangement, for their intimate association, and for the absence of valves. They anastomose freely with the cranial, occipital, vertebral, lumbar, and intercostal veins, the last-mentioned of which, in great part, receive the outflow of the venous blood from the vertebral canal.

The *dorso-spinal* veins lie on the vertebral arches and about the spinous and transverse processes. They receive branches from the deep muscles of the back, and anastomose above with the deep cervical veins, and below with the intercostal and lumbar veins, as well as with the posterior longitudinal spinal veins, through the spaces between the arches.

The *anterior longitudinal spinal* veins form two groups of markedly plexiform arrangement which lie upon either side of the posterior surfaces of the bodies of the vertebræ. Toward the upper portion of the canal, they are continuous with the basilar plexus and the occipital sinus (where the veins composing the plexus are better defined), and anastomose freely with the occipital, intercostal, lumbar, and dorso-spinal veins, as also with the posterior longitudinal spinal, and with one another by transverse veins passing beneath the vertebral ligaments. At this last point they receive the *diploic* or the basi-vertebral vein—or veins, for they are at times double—from the bodies of the vertebræ, and, toward the outer border, minute vessels from the front of the bodies. These may be, however, entirely tributary to the intercostals.

The *posterior longitudinal spinal* veins are smaller and less compact than the anterior. They are better developed below than above, and form anastomoses with the anterior longitudinal spinal, and the lumbar, intercostal, and dorso-spinal veins.

The *veins of the spinal cord* are two in number, an anterior and a posterior. The anterior occupies the anterior median groove; the posterior, the posterior median groove. The latter effects a junction above with the inferior cerebellar vein and the inferior petrosal sinus. (See the Bloodvessels of the Spinal Cord.)

THE VEINS OF THE INFERIOR EXTREMITY.

The Veins of the Inferior Extremity are superficial and deep; they all possess valves, those of the veins of the leg being the more numerous. The *deep* veins of the foot and leg are arranged as venæ comites to the arteries. They converge to form the *popliteal* vein, which becomes continuous with the *femoral* vein, and this in turn with the *external iliac* vein.

Remarks.—All deep veins of the limbs, immediately after leaving muscle-tissue, are apt to undergo an abrupt increase of calibre. Those which pass through a fibrous band or ring are apt to be dilated as they pass from its proximal orifice.—The place at which superficial veins end in the deeper veins, near the line of flexion of joints, is often the place at which some of the deeper veins pass out from muscle-tissue. Owing to this circumstance, the deeper veins are often large near the joints. The region best illustrating the above conditions is that which lies at the upper part of the leg posteriorly. Here the large veins from the Soleus pass from that muscle beneath the fibrous arch extending across the interosseous space, where the popliteal artery ends and the posterior tibial and anterior tibial arteries begin. Congeries of dilated veins thus form about these vessels, and serve as a determining cause for the localization of diseased action in the leg. — In the dissecting-room the writer has often observed these dilated veins pressing against the arteries in subjects in which the injecting fluid had failed to penetrate the anterior and posterior tibial arteries; and in one aged subject, in which the leg and foot were both infiltrated with the products of inflammation, the veins were plugged with clot, and had doubtless exerted pressure against the arteries during life. In connection with this the following case will prove instructive. Mr. Cock[1] observed marked dilatation of one of the posterior tibial veins in a female aged twenty-eight. The condition had been confounded with abscess, and the collection was opened, when its character was determined. The blood was diffused through the popliteal space and thence into the thigh, necessitating amputation of the limb. Examination of the parts showed that the clot had extended half way down the leg.—Verneuil[2] ascribes the tardy recovery so

[1] Med.-Chir. Trans., xxxiv. 328.

[2] Archiv. Gén. de Médecine, Feb. 1877.

frequently remarked in cases of injury of the leg, to the presence of old blood-clots the results of the rupture of veins lying in the calf.—In the study of senile gangrene of the foot and leg, the condition of the deep veins should be carefully considered. Subsequent research may connect the exciting cause of this, and of many of the numerous examples of malnutrition and inflammation of the leg and the foot, with the pressure exerted against the tibial arteries by their varicose accompanying veins. The proximal limitation of the effects of chronic ostitis of the tibia is sometimes found to correspond exactly to the position of the oblique line. While conceding that this may be due to muscular strain of the Soleus (see p. 105), it is not improbable that it may arise from interference with the free entrance of blood into the nutrient canal, the orifice of which is a short distance below the oblique line.—In searching for pyæmic abscesses, the interior of the Soleus and the site of the veins escaping from it should be carefully examined, since many instances of abscess in these regions have been recorded. It is evident that an embolus, moving proximally from a dilated vein of the Soleus, would obstruct the narrowed portion of the vein which lies free at the border of origin of the muscle.

THE POPLITEAL VEIN.

The Popliteal Vein lies behind, that is, superficial to the artery of the same name. In addition to the veins already mentioned, it receives the *short saphenous* as well as those veins associated with the *articular* and *muscular* arteries. The popliteal vein at first lies to the inner side, but subsequently crosses to the outer side of the popliteal artery and terminates in the femoral vein.

Variation.—The popliteal vein is sometimes double.

Remarks.—Both the popliteal artery and vein have been torn through in fracture of the femur above the condyles. Hemorrhage need not follow such an accident, owing to the occlusion of the vessels by the pressure of the end of the proximal fragment. Gangrene of the limb below the point of injury is imminent though it may not occur; a collateral circulation being established, as in ligation of the popliteal artery for aneurism.[1]—A. Bruce[2] records an instance of a popliteal aneurism compressing the popliteal vein, which was incorporated with the outer wall of the sac. In consequence of this pressure, both the superficial and the deep veins of the leg were enormously distended and partially occluded by coagula. The deep tibial veins in this case were so large and tortuous as completely to conceal the artery, which was found, however, on dissection to be occluded by a thrombus throughout its entire extent.

THE FEMORAL VEIN.

After reaching the opening in the tendon of the Adductor Magnus muscle, the popliteal becomes the Femoral Vein. In company with the femoral artery, the femoral vein passes through this opening, the Hunterian canal, at first lying behind the artery, but soon reaching its inner side, and extends proximally as far as Poupart's ligament, where it terminates in the external iliac. It receives the *long saphenous* vein, the *superficial epigastric*, the *external pudic*, and the small *muscular* vein which joins it from behind. Langer[3] describes two or three small collateral veins which sooner or later terminate in the main trunk.

Variation.—The femoral vein is sometimes double.

Remarks.—Violent dislodgment of a clot which had formed in the femoral vein during an attack of phlebitis was observed by F. C. Skey[4] to be followed by death. During the course of an attack of phlebitis of the femoral vein,[5] according to Sibson, the superficial veins over the anterior abdominal wall may become enlarged, as well as those over the buttock and the sacrum. The iliac veins may also be involved. In an extraordinary case of obstruction of the femoral vein in a male aged sixty-eight, Murchison[6] found the

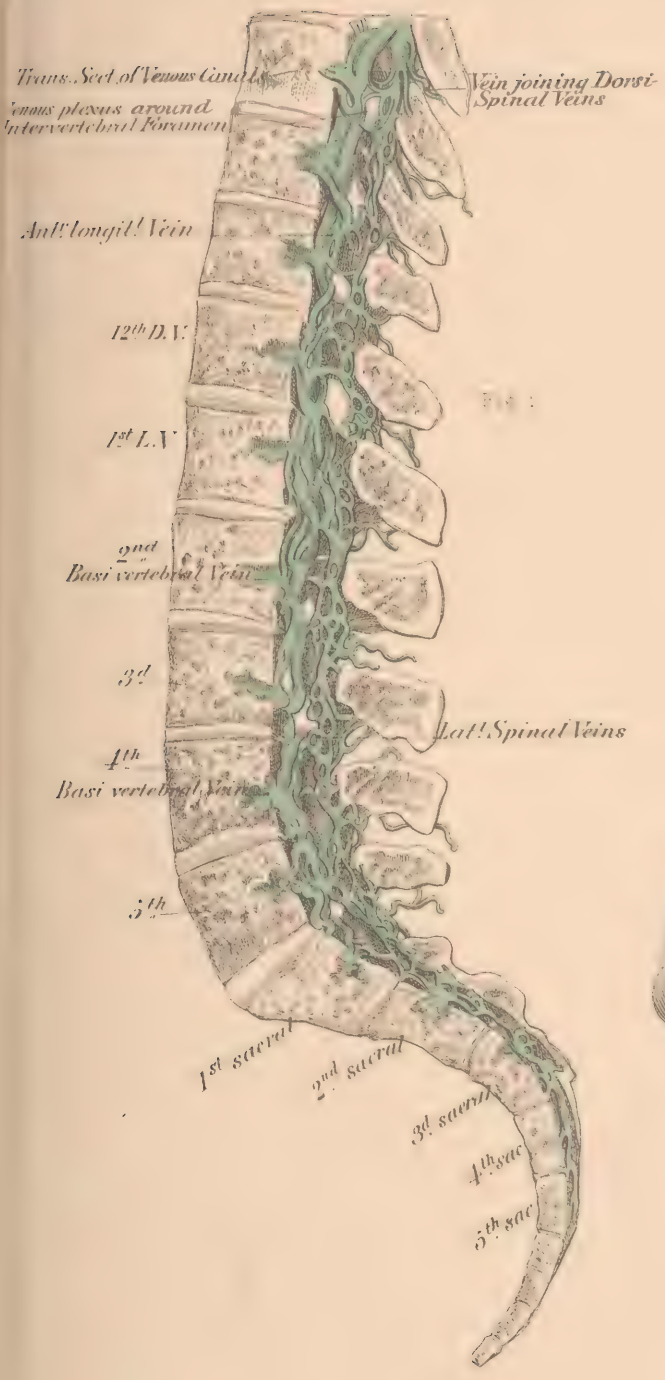
[1] Verneuil, Bull. de la Soc. Anatomique, t. xliv., 1869, 241.
[2] Trans. Path. Soc. Lond., 1867, 83.
[3] Wien. Med. Wochenschrift, 1867, No. 22.
[4] Lancet, Aug. 1870, 247.
[5] Med. Times and Gazette, 1867, 334.
[6] Trans. Path. Soc. Lond., xiv. 1865, 137.

EXPLANATION OF PLATE LXXIII.

Fig. 1. Spinal veins seen in a sagittal section of the vertebral column.

Fig. 2. Spinal veins seen in a horizontal section of the vertebral column.

Fig. 3. The portal system of veins. The portal vein is that portion above the point of reception of the splenic vein—the portion below the junction being the superior mesenteric vein.



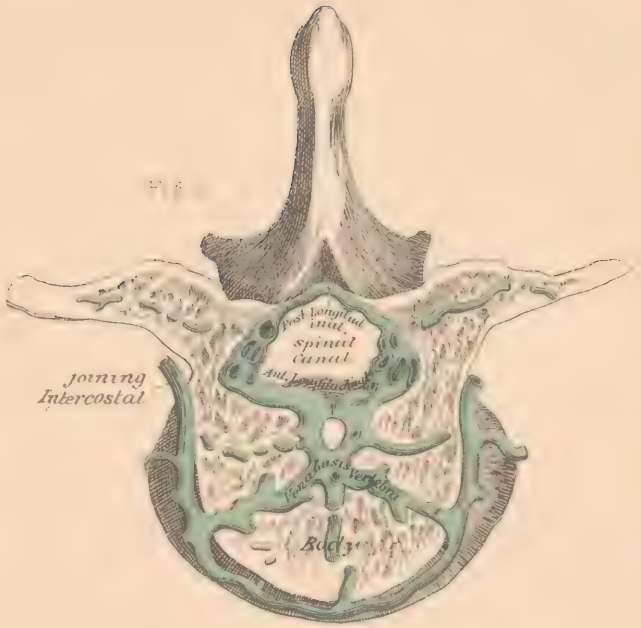


Fig. 3



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cause in a sacculus of the urinary bladder, which had extended laterally as far as the ilium.

According to Braune, the femoral vein lying under Poupart's ligament sucks in the blood from the distal parts at each outward turn of the upper part of the thigh, and empties into the iliac veins at each inward turn, or on flexion.

THE EXTERNAL ILIAC VEIN.

The External Iliac Vein, the continuation of the femoral, lies within the pelvis. It is a short but large trunk, and receives the *circumflex ilii* and the *deep epigastric* veins. The right vein lies behind the external iliac artery, while the left remains to the inner side of its accompanying artery.

The *superficial* veins of the lower extremity are the *long saphenous* and the *short saphenous*. The long saphenous vein begins with the veins upon the dorsum of the foot, which form a wide-meshed network; from the inner side of this network, in conjunction with the veins of the plantar region and great toe, the vein ascends behind the inner malleolus. It soon crosses the leg obliquely to reach the inner border of the calf and the knee; it thence gains the thigh to terminate in the femoral vein, through the saphenous opening of the deep fascia, about one inch below Poupart's ligament. The long saphenous vein receives the *external pudic*, the *superficial epigastric*, and the *superficial circumflex iliac* (*inguinal*) veins.

Variations.—Sometimes the long saphenous receives the short saphenous vein; in other instances it divides, again to unite to form a single trunk, or it may be double throughout its entire length.

The *short saphenous* vein arises from the outer border of the foot, ascends behind the outer malleolus, gains the outer border of the *tendo Achillis*, and thence passes to the posterior surface of the calf of the leg, to terminate between the heads of the Gastrocnemius muscle in the popliteal vein. It is accompanied by the external saphenous nerve, which lies to its outer side.

Variations.—The short saphenous vein may join the long saphenous by piercing either the Biceps or the Adductor Magnus muscle.

Remarks.—Superficial veins are apt to terminate either before reaching the lines of flexion of a joint, or after passing this line, as is seen in the short saphenous vein at the knee, the long saphenous at the groin, and the basilic vein near the axilla. Arteries likewise are apt to divide or give off large branches after passing this line, as is seen in the brachial, femoral, and popliteal arteries.

J. Gay[1] believes that the superficial and deep veins of the limbs do not communicate, save at the points of termination of the former. Jno. Hutchinson[2] has, however, described a general enlargement of the superficial veins in a male aged thirty-six, following, as was supposed by the observer, obliteration of the deeper trunks from rheumatic fever.—In the course of an operation for removing a fibroid tumor from the thigh, the long saphenous vein was found by McClellan[3] to be enormously enlarged.

The same vein, as it lies at the lower third of the thigh, was found by the writer[4] to be inflamed in a number of inflammatory conditions of the lower extremity. The following comments may be found useful in connection with this subject.

A slight amount of inflammation, with thickening, is apt to occur in the connective tissue about an inflamed vein. In subcutaneous phlebitis the brawny red line in the skin is indicative of this—the cord-like induration of the vein alone being expressive of the phlebitis proper. At certain points the periphlebitis may become circumscribed and pass on to suppuration, but more commonly it retains its diffuse character, and may extend up along the tract of the vessel beyond the limit of the involved vein itself.

This latter tendency the writer has noticed in a stump of the right foot—the patient dying of pyæmia following amputation through the tarsus. The tissues at the inner side of the ankle were infiltrated with serum, but the veins lying along the internal plantar artery and between the abductor of the great toe and the short flexor were conspicuously swollen and inflamed. The tract of the posterior tibial vessels and nerve was infiltrated with serum, the tissues being matted together.

When the veins are deeply situated, as in the intermuscular spaces, they are more liable to serve as conductors of inflammation than are the superficial veins, which, being held more firmly in position by the deep fascia of the limb, are obedient to the general rule, that the nearer the parts lie to the surface, the more compact is their connective tissue. The comparative rarity of subcutaneous phlebitis, when the vast number of lesions capable of producing it is considered, is remarkable, and affords an instructive contrast to the frequency of this complication after

[1] Trans. Path. Soc. Lond., 1879, 323.
[2] Br. Med. Journ., 1871, 118.
[3] Surgery, p. 194.
[4] Phila. Med. Times, i. 1871, 433.

amputations and resections of bone. The general statement that phlebitis is more common in the superficial than in the deep-seated veins is only correct as far as the absolute number of cases observed is concerned. When compared with reference to their relative liability to become inflamed, the deep-seated are by far more apt to be selected, either primarily, through their own coats, or, secondarily, by periphlebitis in the soft connective tissue about them.

When the short saphenous empties into the popliteal vein, as is the rule, ulcerations along its tract are very rare. When, however, the vein joins the internal saphenous, it becomes more liable to disease, and ulcers are very apt to appear along its course, especially at the outer side of the ankle.[1]

The long saphenous vein is so commonly the seat of moderate dilatation in females that the terms "Frauenader" and "Rosenader" are of frequent occurrence in the descriptions of this vein in the writings of German clinicians and anatomists.

THE COMMON ILIAC VEIN.

The Common Iliac Vein is associated with the common iliac artery of its own side. Each vein is formed by the convergence of the corresponding internal and external iliac veins. The left is longer and more oblique than the right. Each vein terminates in the inferior vena cava opposite the interval between the fourth and fifth lumbar vertebræ. The left receives from the hollow of the sacrum a small vein known as the *median sacral*. The relations of the iliac vein are of importance in the operation of ligating the common iliac artery. The left vein lies to the inner side of its artery and passes beneath the right common iliac artery to gain the inferior vena cava. The right vein lies at its origin behind the corresponding artery, but soon gets to its outer side.

The two iliac veins may remain distinct until they receive the renal veins.

THE INTERNAL ILIAC VEIN.

The Internal Iliac Vein is a short thick trunk directed inward and backward, in front of the sacral plexus and the Pyriformis muscle, but on a plane behind that of the corresponding artery. The internal iliac vein is without valves, though its tributaries are rich in them. It receives blood from parietal and from visceral branches. The blood supplied by the *parietal* branches of the internal iliac artery is returned through the double veins (venæ comites) of the ilio-lumbar, the superior and inferior gluteal, the lateral sacral, the obturator, the internal pudic, and the sciatic arteries.

The *visceral* branches, comprising those derived from the pelvic organs, are plexiform. They form usually close-meshed and intricate networks within the walls of the bladder, genital organs, and rectum, and finally terminate in the internal iliac vein. Exceedingly free anastomosis exists between the several networks.

The veins joining them are the lateral sacral, the pudic, and the dorsal vein of the penis; while the networks themselves are called the *sacral*, the *hæmorrhoidal*, and the *vesical* plexuses. The female has a special plexus, the *utero-vaginal*, and the male another, the *prostatic*.

The *lateral sacral* vein on either side anastomoses with branches of the median sacral, and forms a diffuse plexus lying upon the anterior surface of the sacrum. A portion of this plexus joins the common iliac through the median sacral vein; the remaining vessels join the internal iliac vein; they may empty into the ascending lumbar.

The *pudic* vein is smaller than the artery of the same name. It collects blood from the parts about the perineum and the base of the penis.

The *dorsal veins of the penis* tend to be symmetrical, though there may be but one. When two exist, they lie to the outer side of the dorsal arteries. The vein receives distinct branches from the spongy and cavernous bodies; those from the former join it from behind the corona glandis, while the others emerge from the under border of the cavernous body, and pass upward around the sides of the penis to terminate in the main trunk.

The dorsal vein pierces the sub-pubic ligament, and divides into two branches, one on either side of the prostate gland, to join the prostatic plexus. The veins of the clitoris are analogous to those of the penis, and are received by the *utero-vaginal plexus*.

J. Gay[1] concluded, from a careful study of the veins in a case of gangrene of the cavernous and spongy bodies where the integuments remained intact, that the venous currents from the deep structures of the penis have no outflow towards the heart save through the deeper veins; so that obstruction in these is fatal to the body of the penis but not to its tegumentary covering.

The *hæmorrhoidal plexus* lies beneath the mucous membrane of the rectum, and is best developed at its lower portion. It gives origin to the *superior*, *middle*,

[1] Bozeman, N. Y. Med. Journ., xviii. 360.

[1] Trans. Path. Soc. London, 1879, 323.

and *inferior hæmorrhoidal* veins, which accompany the arteries of the same name. The superior hæmorrhoidal is tributary to the inferior mesenteric vein, to the middle, to the inferior, and to the internal iliac vein. The plexus effects anastomosis with the vesical, with the utero-vaginal, and with the prostatic plexus. At the anus the veins are arranged in three sets, namely, about the External Sphincter (peri-sphincteric), beneath the skin, and beneath the mucous membrane. (See Plate LXXIV.)

The *vesical plexus* embraces the veins of the bladder. It anastomoses with the hæmorrhoidal and the prostatic plexus in the male, and with the utero-vaginal plexus in the female.

The *utero-vaginal plexus* surrounds the vagina and uterus, and passes thence along the broad ligament of the uterus toward the ovary, where it anastomoses with the ovarian veins. The veins of this plexus, being connected with the uterine sinuses, become enormously dilated during pregnancy.

The *prostatic plexus* is situated at the sides and base of the prostate body, at the neck of the bladder, and along the membranous portion of the urethra. It receives the dorsal veins of the penis at the sides, and anastomoses with the veins from the vesical plexus and with the veins of the vesiculæ seminales.

Remarks.—The branches of the internal iliac vein aid indirectly in supporting the pelvic viscera. They are apt to be varicose in the aged, particularly in females. The blood of a pelvic hæmatocele is derived from these veins.

THE INFERIOR VENA CAVA.

The Inferior or Ascending Vena Cava (Plate LXVI.) is formed by the confluence of the primitive iliac veins. It extends from a point between the fourth and fifth lumbar vertebræ to the ninth dorsal vertebra. At the posterior border of the liver between the Spigelian and right lobes, the vessel lies within a groove in the hepatic substance known as the hepatic groove. Beyond this groove it passes through the Diaphragm by a special opening, and, penetrating the pericardium, empties into the right auricle. It is convenient to name that portion of the ascending cava above the Diaphragm the thoracic, and that below the Diaphragm the abdominal portion.

The inferior vena cava lies at first upon the vertebral column, and rests then upon the right crus of the Diaphragm, having the aorta to the left; the base of the mesentery, the horizontal portion of the duodenum, and the pancreas being in front. At its origin, it is in contact with the aorta; above, it lies to the right side; and in the epigastric region a considerable interval is defined between it and the aorta; in this interval are seen the thoracic duct, the right azygos vein, the right crus of the Diaphragm, and the Spigelian lobe of the liver. It is covered in front by the peritoneum within the abdomen, and by the serous layer of the pericardium in the thorax.

While within the groove in the liver the inferior vena cava is almost surrounded by the hepatic substance, and is firmly held to the parenchyma by connective tissue. The inferior vena cava, besides the common iliac veins, receives the lumbar, renal, right supra-renal, right spermatic, ovarian, inferior diaphragmatic, and hepatic veins.

The *lumbar veins* are derived from the veins of the back and walls of the abdomen. They have for the most part a loose plexiform arrangement (lumbar plexus) in the region of the loin. One of the largest vessels (*ascending lumbar*) ascends vertically beneath the Psoas Magnus muscle to empty into the right azygos or the left azygos vein.

The *renal veins* (emulgent veins) are two in number, the right and the left. They are large, but short trunks, and lie, as a rule, in front of the arteries of the same name. The left is slightly higher than the right, and receives the blood not only from the left kidney, but from the left spermatic and supra-renal veins. It crosses the aorta in front to join the cava, but lies behind the superior mesenteric artery.

Each vein, as a rule, is protected by a valve at its orifice. The left renal vein was found to be impervious in a case reported by Andrew.[1] The blood was returned in part by the lumbo-sacral veins, and in part by the left supra-renal vein. Thrombosis may occur here and involve the whole length of the vessel.

The renal vein occasionally receives minute branches from the capsule and the surrounding fat. The left renal frequently anastomoses with the left azygos, and may be double, when one will be found behind and the other in front of the aorta. At times the single left vein will pass behind the aorta. To this occurrence may be attributed the greater frequency of hyperæmia of the left kidney. When the inferior vena cava is absent, the renal vein joins the right azygos or the left azygos vein. The renal vein in rare instances receives an abnormal mesenteric

[1] Trans. Path. Soc. Lond., 1865, 92.

vein. Infrequently the veins are occupied by coagula in renal disease.

The *supra-renal veins* are relatively large. They pass obliquely downward, the right emptying into the vena cava, the left into the left renal.

The *spermatic veins* arise from the body of the testicle and the epididymis. At first having the form of a plexus (*plexus pampiniformis*), the spermatic veins from each testicle converge to form four vessels, which, as they reach the external inguinal canal, decrease to two or three, and finally within the abdomen all the blood is collected by one vein. The vein on the right side empties into the inferior vena cava; that on the left into the left renal vein.

The fact that varicocele is almost invariably confined to the left side indicates the presence of a local cause. Dr. Jno. H. Brinton,[1] of Philadelphia, has suggested that it lies in the frequent absence of the valve at the orifice of the left renal vein. According to W. Rivington,[2] valves ordinarily exist at the orifices of both spermatic veins. When the orifice of the left vein is without a valve, one is often found at the orifice of the left renal within a quarter of an inch of the orifice of the spermatic. In the opinion of Luschka, the sigmoid flexure, when loaded with hardened feces, may exert so much pressure upon the vein as to induce varicosity independently of other causes. Rarely the spermatic veins empty into the left azygos vein, or even into the external iliac.

The *ovarian veins* are the representatives in the female of the spermatic veins. They may end either in the vena cava or in the renal vein. They derive blood from the ovary, and are in intimate communication with the uterine plexus. In pelvic phlebitis, the ovarian veins may be inflamed their entire length, and be occupied by coagula or detritus. Some of the English writers include the ovarian veins under the same head as the spermatic.

The *inferior diaphragmatic veins* are generally two in number, and are associated with the arteries of the same name. They open directly into the cava, or rarely into the hepatic or the suprarenal vein.

[1] Am. Journ. of Med. Sci., xxxii. 1856, 111.
[2] Journ. of Anat. and Phys., vii., 1873, 163.

The *hepatic vein* joins the cava at an acute angle, immediately before that vessel enters the thorax. It is a short but important trunk, which receives the blood from the liver. It is without valves. The flow of blood from the vein to the cava is influenced by the movements of the Diaphragm, the descent of this muscle tending to constrict the opening through which the vein passes.

While a valve at the orifice of the hepatic vein is absent in the adult, it commonly exists in the human fœtus and in many animals. The vein is subject to but few variations. It has been known to join the right azygos vein, the common trunk entering the right auricle, and the inferior vena cava being absent.[1]

Remarks.—The inferior vena cava can be studied with advantage from the following points of view:—

(1) The establishment of a collateral circulation after occlusion of the vessel.

(2) Localization of diseased action as determined by the reception of the blood from the renal veins.

(3) The same as determined by the reception of blood from the hepatic portion of the trunk.

(4) The same as determined by diseases of the kidneys.

(5) The congenital variations of the vessel and its tributaries.

(6) The localization of morbid growths and injuries.

(1) When the inferior vena cava is occluded, as by pressure from an aneurism or other tumor, or by inflammation, the blood from the extremities and from the pelvic and abdominal organs may reach the heart in a variety of ways. The following examples are given in illustration of this subject:—

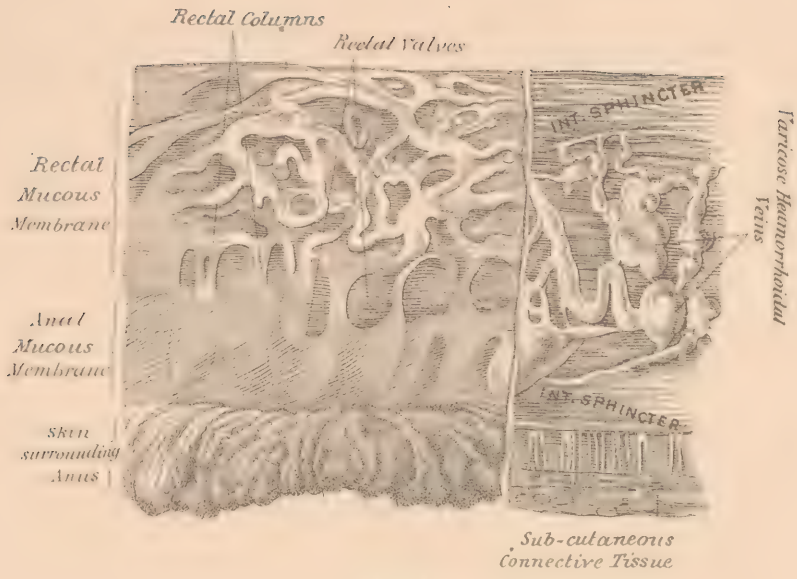
In a case reported by Gely,[2] the blood from the superficies of the right lower extremity passed along the superficial abdominal veins and the external mammary vein to the superior cava. The blood from the deeper portions of the same limb passed into the abdomen by a large vein accom-

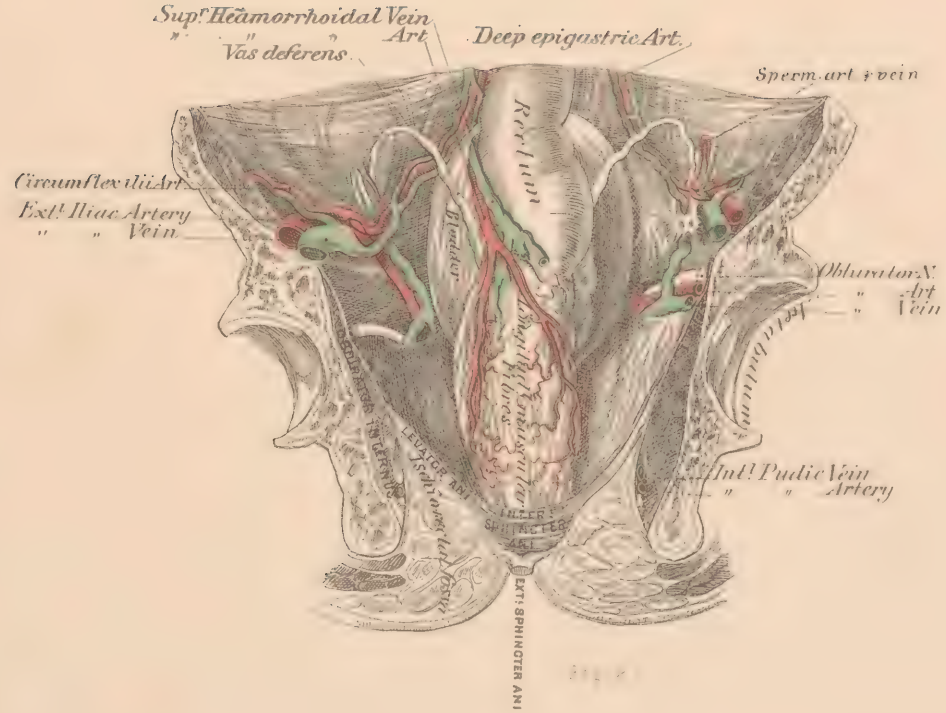
[1] Wistar's Human Anat., ii. 320; also W. Horner, Journ. of the Acad. Nat. Sci. of Phila., i. 1818, 401; and J. Abernethy, Phil. Trans., xvii. 296, 1809.
[2] Gaz. Méd. de Paris, Nov. 7, 1841.

EXPLANATION OF PLATE LXXIV.

Fig. 1. A diagrammatic representation of the arrangement of the hæmorrhoidal veins and of the rectal and the anal mucous membrane.

Fig. 2. The anterior aspect of a frontal section of the pelvis, showing the rectum, the bladder, the pelvic arteries and veins.





T. Sinclair & Son Lith.

panying the crural nerve. It then entered the lumbo-vertebral veins, thereby reaching the inferior cava above the constriction. The blood of the superficies of the left lower extremity was returned as in the right. That of the deeper parts, however, passed upward by way of the deep epigastric vein, and thence to the portal vein and inferior cava at the upper portion of the abdomen by an open umbilical vein.

In a second case, recorded by M. Raynaud,[1] the inferior cava was obliterated for three inches from its termination, as were also the hepatic and the right branch of the portal vein.

In a case of occlusion, described by James Wilson,[2] several vessels passed from the liver to the right auricle. The superficial abdominal and axillary veins were enormously enlarged, and emptied into the right azygos vein. The cava was occluded from the renal veins to a point just below the hepatic vein, as a result of acute inflammation. The renal, spermatic, and primitive iliac veins were impervious. Anastomosis occurred between the saphenous vein and the veins accompanying the muscular twigs of the femoral artery; the blood thus reaching the obturator vein was carried through the obturator foramen, and thence by the lumbo-vertebral veins to the azygos, and thus to the superior cava. A second anastomosis existed which connected the pudic veins with the inferior mesenteric, and thus with the portal vein.

In a case of Haller's,[3] the vena cava was obliterated between the renal and iliac veins. The right spermatic vein was enormously enlarged, and received blood from the ureteric vein of the same side.

In a case of Baillie's,[4] in which the inferior cava was obliterated from the renal vein to the right auricle, the renal and diaphragmatic veins opened into the lumbar and azygos, by means of which communication the blood of the abdomen gained the superior cava.

Both the umbilical and urachal veins may remain open, and a varicose tumor may form about the umbilicus in obstruction of the deeper venous trunks.[5]

(2) Thrombosis may extend throughout the entire length, or may be limited to a portion only of the vessel. In the latter instance the clot may extend from the renal vein to the auricle, as in the cases of Wilson and Baillie above cited, or it may extend from the iliac vein to the line of the orifices of the renal veins, as in the cases of Haller and Thompson. In a case reported by Coyne and Trosier[6] the vessel was compressed by a cancerous mass springing from the left kidney. The left renal vein and the inferior cava from this point to the auricle were occupied by a recent soft clot, while below the orifice of the left renal the vessel was filled and obliterated by an old and firm clot. It would appear from these and from analogous cases that the formation of a thrombus in the inferior vena cava is modified by the blood flowing from the kidney into the cava. Blood drawn from the renal vein is poor in fibrin, and coagulates imperfectly. Hence, a stream of renal blood pouring into the cava may modify, under favoring conditions, the process of coagulation going on there.

(3) The cava as it passes along the hepatic groove may easily be influenced by morbid processes originating in or about the liver. The vessel may be obliterated by a hydatid cyst or by a carcinomatous growth. An instance of such occlusion has been recorded by Dr. Wm. Gull.[1] The venous blood from points below the constriction had been returned by the azygos vein to the right side of the heart. Fibrous growths originating in the liver may compress the hepatic vein and the vena cava as they pass in the hepatic groove. In a specimen described by S. Wilks,[2] while the lower part of the cava was of usual size, it was encroached upon as it lay in contact with the liver, and much diminished in calibre. Intruding into its interior was a hard fibrous nodule. Near this, two contracted hepatic veins were seen. Luschka mentions an instance in which a hydatid cyst lodged within the liver near the hepatic vein had burst, and in which the echino-cysts, passing into the cava at its hepatic portion, were carried to the right side of the heart, and thence to the pulmonary artery, where they caused obstruction and death. In a case of hepatic hydatid cyst pressing against the cava, not only was the trunk occluded, but ulceration of its coats ensued.[3]—Rupture of the liver from external injury may involve the inferior cava.—In thrombosis of the cava the clot may be firmer as the vessel lies within the hepatic groove.

(4) In all cases of thrombosis of the cava the condition of the kidney should be ascertained. The case of Luschka[4] in which a constricted cava was associated with Bright's disease, and numerous instances in which infarction of the parenchyma of the

[1] Nouv. Dict. de Med. et de Chir. prat., iv. 385.

[2] Trans. of Soc. for Imp. of Med. and Chir. Knowledge, iii. 1812, 65.

[3] Loc. cit., iii. 70.

[4] Loc. cit., i. 1793, 125.

[5] Xavier Gouraud, Bull. de la Soc. Anat., 1863.

[6] Bull. de la Soc. Anat., 1871, t. 46, 239. For additional cases of obliteration, and literature to 1845, see T. B. Peacock, Med.-Chir Trans., xxviii. p. 1.

[1] Lancet, 1864, 379.

[2] Trans. Path. Soc. London, 1863, xiii. 124.

[3] Bull. de la Soc. Anatomique, 1855, 254. See also Frerich's Diseases of the Liver.

[4] See p. 438.

kidney has been found associated with inflammation or thrombosis of the cava, might be mentioned in relation to this subject.

(5) The *congenital variations* of the inferior cava include the following: The vessel may incline to the left of the aorta at the lower part of its course, but may enter the Diaphragm to the right.

It may arise opposite to the kidneys, or just beyond them, an arrangement due to the fact that the iliac veins remain ununited until they have reached this point.

In a case described by James Jeffray,[1] the inferior cava was absent. The left azygos vein continued upward in the thorax to join the superior cava a short distance above its termination. It received the lumbar and intercostal veins. The hepatic vein opened into the right auricle. The hemiazygos vein passed from the left side of the inferior cava below the heart to the left subclavian vein. The right innominate vein was smaller than the left.

Rothe[2] describes an instance in which one of the hepatic veins entered the right ventricle, its orifice being supplied with valves.[3]

Since the inferior cava does not appear until the inferior extremities have developed, some correlation between anomalous conditions of the external iliac vein and inferior cava, and the variations in the structure of the limb, might be expected. No such relations, however, have hitherto been observed by anatomists, nor has any connection been traced between the variations in the course of the cava and the vessels of the lower limbs.—The internal iliac vein in the embryo forms part of the system of cardinal veins, and changes its point of termination only after the development of the extremity. As a rare anomaly, the internal iliac retains its connection with the cardinal veins by emptying into the azygos or the hemiazygos vein, when the external iliac and the inferior cava form a single trunk.

As a rule, it may be said that, when any of the tributaries of the inferior cava fail to join the main vessel, they will be found to join the azygos vein, or, in the case of the hepatic vein, the right auricle.

When the cava is congenitally absent, the azygos vein takes its place. But, when the vessel is obstructed or obliterated by acquired conditions, the connection with the azygos is not reopened; still, as seen in the above cases, the radicles of communication between the epigastric and mammary veins are enlarged, and seem to convey the blood from below the obstructed point to the heart.

The venous blood passing from the renal vein into the vena cava evidently exerts considerable influence over the variations of that vessel. Anomalies may be restricted to the cava from its origin to the orifices of the renals, or may be confined to the cava from the orifice of the renals to the Diaphragm, or from the same point to the termination of the cava in the right auricle. Dr. W. Ogle[1] dissected a subject in which the lumen of the cava from the renal veins to the Diaphragm was obliterated. The blood was returned chiefly by the azygos veins and the portal vein.

(6) In a man thirty-three years of age, a ball-like phlebolith was found growing from the inner wall of the right auricle at its junction with the inferior vena cava. A portion of it projected into the auricle and a portion into the cava, reducing the calibre of the vessel to a narrow crescentic slit. Luschka[2] attributed the occurrence of Bright's disease in this subject to the resulting interruption of the return of blood from the kidneys.

Thrombosis of the inferior cava has been noticed as a result of compression from a misplaced kidney.[3] H. Thompson[4] records the case of a young girl who suffered from the lodgment of a needle in the inferior cava. Thrombosis existed from the orifices of the renal veins to the lower extremity of the vessel. Phlegmasia dolens of the left lower extremity ensued on the fourteenth day after the appearance of constitutional symptoms. A short time before death, which occurred on the fifty-third day, phlegmasia appeared in the right lower extremity. The selection of the left side for the first invasion of the phlegmasia may have been caused by the peculiar relation existing between the left internal iliac artery and the external iliac vein (*q. v.*).

From the fact that œdema does not necessarily ensue in these cases, and that no collateral trunks are found to be established, it is likely that a thrombosis may after death present the appearance of having occluded the vessel, although the obstruction may not have been absolute during life.

[1] Glasgow Med. Journ., i. 1828, 1, figs.

[2] Act. Acad. Joseph. Méd.-Chir. Vindobonensis, i. 1788, 233, fig.

[3] For an elaborate account of the variations of the inferior cava, the reader may consult W. Krause, Henle's Anat., iii. Bd. 380.

[1] Journ. of Anat. and Phys., xiii. 291.

[2] Virchow, Archiv, vol. lvi. 1872, 176, fig. See the researches of Frerich and Robinson; also R. McDonnell, Brown-Séquard's Journ. de la Physiologie, ii. 1859, 300.

[3] Delafield, Handbook of Post-Mortem Examinations, 207.

[4] Trans. Clinical Soc. of London, viii. 1874, 23.

The inferior cava is infrequently the seat of direct lesion. It may be ruptured by external violence, and more frequently as it lies in the hepatic groove than elsewhere. From the proximity of the vessel to the right Psoas muscle, it is not surprising that the fatal issue in advanced stages of psoas abscess may be precipitated by ulceration in the walls of the vessel. Butcher[1] mentions this result as having occurred in a girl aged six years, who suffered from psoas abscess of the right side. It is evident that a similar condition would be unlikely to occur on the left side.

In a child aged twelve years, rupture of the inferior cava was caused by a wagon passing over the body. The rupture was small. Blood was found in the retro-peritoneal space, but none in the abdominal cavity.[2]

THE PORTAL SYSTEM OF VEINS.

The Portal System of Veins (fig. 3, Plate LXXIII.) includes—

I. The Portal Vein (before it is received within the Liver) and the Tributaries of the Vein.

II. The Subdivisions of the Portal Vein within the Liver (see account of the Liver).

I. The Portal Vein, before it is received within the liver, conveys blood from the alimentary canal and related appendages below the Diaphragm, as well as from the spleen.

The main branches or tributaries are as follows:—

Superior Mesenteric.
Inferior Mesenteric.
Gastric.
Splenic.
Cystic.

The *superior* and *inferior mesenteric* veins accompany the arteries of the same name. The trunk of the superior mesenteric vein ascends, with a slight inclination to the right side, between the duodenum and the pancreas.—The inferior mesenteric vein anastomoses freely below with the superior hæmorrhoidal veins, and through these with the subcutaneous veins at the anus. The main trunk is formed at the sigmoid flexure, and usually lies in a falciform fold of peritoneum, which extends from the duodenum to the jejunum, and terminates in the trunk of the portal vein, near the point of entrance of the splenic vein. Luschka describes this vein as a tributary of the splenic vein. The inferior mesenteric vein lies in front of the renal vessels, and, at its termination, behind the pancreas.

The *gastric* veins are two in number: the *coronary* vein, which extends from the cardiac to the pyloric end of the stomach; and the *right gastro-epiploic* vein, which is associated with the artery of the same name.

The *splenic* vein derives its blood from the spleen, in part from the cardiac end of the stomach through the veins accompanying the vasa brevia and the *left gastro-epiploic* vein, and from the pancreatic veins. The splenic vein crosses the superior mesenteric artery at its origin, and as it lies between the spleen and the left end of the pancreas is in association with the splenic artery, being invested with the same fold of peritoneum. Clinical writers have occasionally applied the term "splenic cord" to this fold and its contents. In hypertrophy of the spleen, and in tumors of the pancreas, the "splenic cord" may be compressed, the artery contorted, and stasis of the return blood from the spleen induced.[1]

The splenic vein joins the superior mesenteric vein at a right angle, being less curved than the splenic artery, below which it lies. Rarely, it is doubled near its end. The vessel lies immediately behind the pancreas, and is parallel with its axis. Luschka describes a *pancreatico-duodenal* vein which, deriving blood from the pancreas and the greater part of the duodenum, passes along the concavity of the duodenum, and either empties into the main trunk independently, or joins the superior mesenteric vein. In mammals, it generally opens into the main trunk at the transverse fissure.

To the above tributaries of the portal vein may be added a small vessel, the *cystic* vein, coming from the gall-bladder.

The main trunk of the portal vein measures about three inches in length, and extends somewhat obliquely upward to the right, from the head of the pancreas to the transverse fissure of the liver, which it enters. Immediately prior to its termination, it expands slightly, constituting the *sinus* of the portal vein. Within the liver the vein breaks up into numerous branches, which are lost within the parenchyma (see Liver).

The vessel lies between the two layers of the lesser omentum, at its right border. It lies behind the pancreas, and behind and between the hepatic artery and the common bile-duct, the latter being to the

[1] Essays and Reports on Operative and Conservative Surgery, Dublin, 1865.

[2] Wharton, Dub. Quart. Journ., xlix. 1870, 501.

[1] See, in connection with this, Med. Times and Gaz., 1869, 18.

right side. About it are numerous lymphatic glands and filaments of the hepatic plexus.

Baccelli suggested the theory that, at times of gastric repletion, the splenic vein is compressed by the stomach and temporarily occluded. The flow of the return blood from the spleen is, under such circumstances, impeded; the organ becomes turgescent, and the blood is forced to pass through the small veins accompanying the vasa brevia to the veins in the walls of the stomach. It is supposed both by this observer and by Schiff that the spleen, while thus turgescent, eliminates a special substance (peptogen of Schiff) which furnishes to the peptic gland the material from which pepsin is secreted. Baccelli further traces the connection existing between the above conditions of the spleen and the states of health of malarial subjects.

Variations.—The most variable veins of the portal system are those connected with the spleen. When accessory spleens exist, each spleen is apt to return its blood by a separate vein which is tributary to the splenic. The inferior mesenteric vein may join either the splenic near its termination, or the superior mesenteric vein; it may receive the utero-vaginal vein. In the examination of subjects known to have exhibited clinical relations between conditions of the rectum, the spleen, and gastric digestion, it would be rational to search for variations in the inferior mesenteric vein, with respect to the place at which the splenic and the inferior mesenteric veins may have joined.

The portal vein in rare cases opens directly into the vena cava, near the level of the renal vein, without entering the liver. This peculiarity may coexist with transposition of the viscera.[1] Dr. Robert McDonnell[2] describes a valve composed of two segments in the vena cava at the orifice of the renal vein. Attention was directed by Dr. John H. Brinton[3] to the presence of this valve at the orifice of the right renal, and to its absence at the orifice of the left. When no valves exist at the opening of the left spermatic vein, they are generally present in the renal, within a quarter of an inch of the orifice of the spermatic. The ovarian vein has been found to present a similar peculiarity.[4]

[1] John Abernethy, Philosoph. Transactions, xvii. 1809, 296, figs.
[2] Glasgow Med. Journ., ii. 1854, 285.
[3] American Journ. of the Med. Sci., xxxii. 1856, 111, figs.
[4] W. Rivington, Journ. Anat. and Phys., vol. vii. 1873, 163.

The portal vein may retain its anastomoses with a persistent umbilical vein,[1] and with the epigastric vein at the umbilicus. When the last-named communication exists, the enlargement of the veins about the umbilicus and in the hypogastric region enables the observer to detect the condition in the living subject. The veins may be seen in the healthy individual forming clusters about the umbilicus (*caput Medusæ*), or extending from the umbilicus to the groin. When the portal circulation is obstructed by cirrhosis or by analogous conditions of the liver, the enlargement of a small and previously unrecognized epigastric vein may create pronounced varicosities.

Remarks.—The relations of the portal vein and its tributaries to practical medicine can be conveniently included under the following heads, viz.:—

(1) Occlusion of the trunk.
(2) The establishment of a collateral circulation.
(3) Lesions of the vein.

(1) The portal vein may be occluded either by pressure from without, or by a thrombus. *Pressure from without* may be produced by enlarged lymphatic glands about the aorta, when the common bile-duct may also be involved,[2] or it may arise from the presence of concretions in the gall-bladder.—In a well-marked example of this morbid condition, A. S. Donkins[3] found that the posterior extremity of the gall-bladder rested in the transverse fissure, over the portal vein at its entrance into the liver, causing partial obliteration of the vessel. The tributaries of the portal vein were found distended, the spleen was engorged, and extravasations of blood existed between the great omentum and the ascending meso-colon. The gall-bladder contained a number of calculi, but no bile.

Occlusion of the portal vein and its tributaries from *thrombosis* is a frequent accompanying condition of diseased action in the abdomen.[4] Usually the result

[1] See p. 414. J. A. Russel (Journ. of Anat. and Phys., 1873, 149) describes two cases.
[2] M. Pozzi, Bull. de la Soc. Anat., 1870, t. 45, 277.
[3] Med. Times and Gaz., 1868, 396.
[4] See Fenwick on the Stomach and the Duodenum; also R. Virchow, Trans. Würzburg. Phys. Med. Soc., 1857, vii. 21.

EXPLANATION OF PLATE LXXV.

Fig. 1. The veins and lymphatics of the upper extremity.
Fig. 2. The veins and lymphatics of the foot and the leg.
Fig. 3. The veins and lymphatics of the upper portion of the leg, the thigh, and the external genitals.

Fig 1

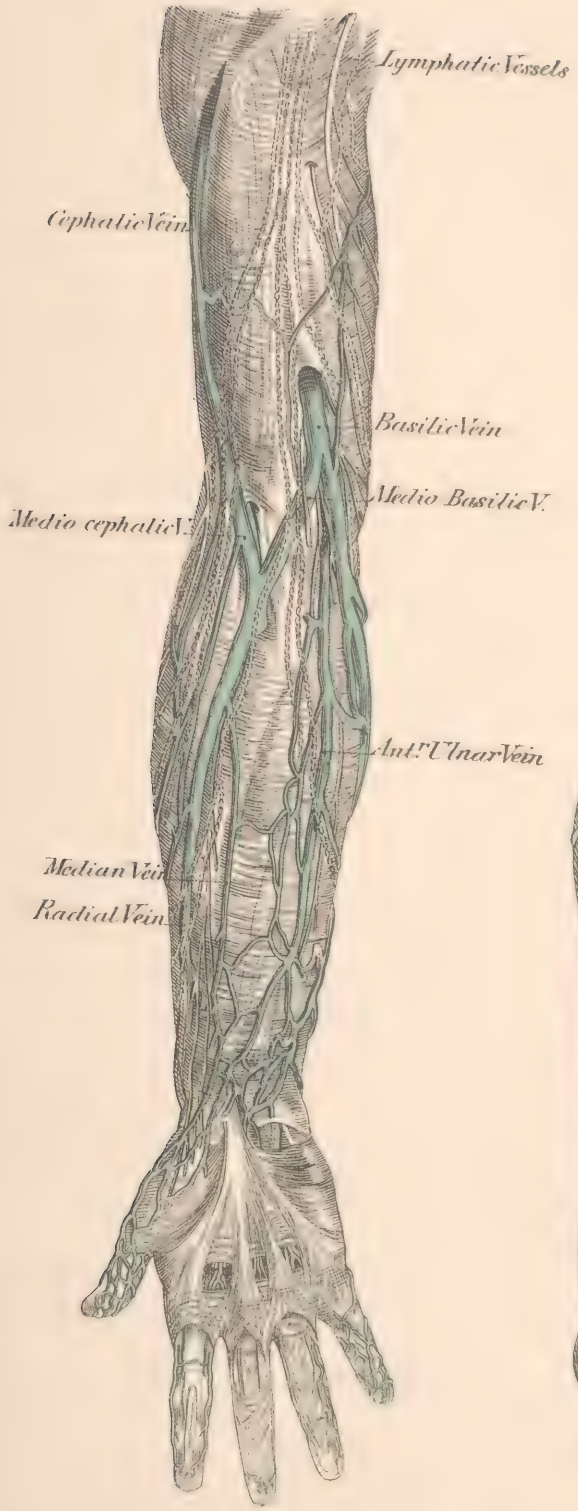


Fig 2

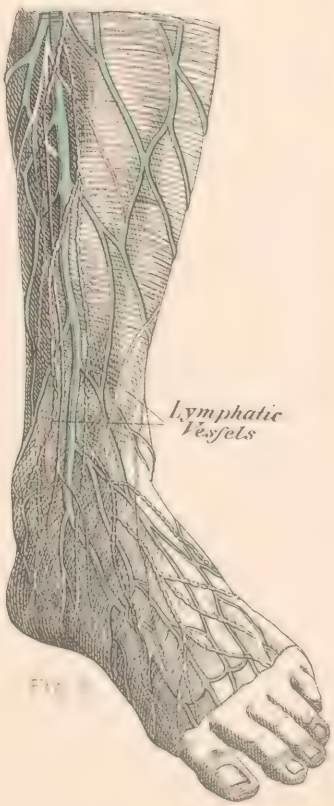


Fig 3

T. Sinclair & Son, Lith.

of idiopathic inflammation, occlusion may be caused by calcification of the vein. A projecting portion of such deposit will serve as the exciting cause for the formation of a clot.—A thrombus may extend from the umbilical into the portal vein. All the hepatic branches of the portal vein may be obliterated. Such a condition may ensue upon cancerous infiltration of one of the abdominal organs, under which circumstances it is reasonable to assume that the hepatic branches of the vein have been plugged by emboli detached from the seat of diseased action.[1]

The extraneous sources of occlusion of the branches of the portal vein passing through the liver embrace, besides pressure, as from tumors, the causes which contract the parenchyma; so that all forms of atrophy and interstitial hyperplasia may be accepted as factors in occluding the portal branches, giving rise to stagnation of the blood-stream and to the consequent establishment of a collateral circulation.

The formation of hepatic abscess dependent upon dysentery or upon other acute inflammatory process of high grade is probably determined by the plugging of the hepatic branches of the portal vein with thrombi.

(2) In the study of the *collateral circulation*, it is necessary to remember that the portal vein does not return all its blood through the liver. Even should the ductus venosus be no longer patulous, a few unimportant branches about the cardiac orifice of the stomach anastomose with the inferior œsophageal and the inferior diaphragmatic veins.[2] Occasionally a few small vessels will pass directly to the inferior vena cava without entering the liver. Three cases have been recorded in which none of the portal blood entered the liver, but passed directly into the cava.—Schiff and Sappey show that a small vein, formed on the anterior abdominal wall by union of the epigastric and other veins, ascends parallel with the remains of the umbilical vein, and, deriving blood from the abdominal muscles and the peritoneum, joins the portal vein near its termination. Luschka found that this vein affects more particularly the division of the portal vein going to the left lobe of the liver. In cirrhosis of the liver, the portal blood is returned in part by the cutaneous veins of the abdomen.—When the liver is abnormally adherent to the Diaphragm, the diaphragmatic veins may carry some of the portal blood to the azygos vein. In cases of enlargement of the azygos vein, it would be of great interest to observe the changes effected in the diaphragmatic and œsophageal veins in regard to their supplementary action as carriers of portal blood.

(3) The *lesions of the portal vein* are infrequent. The following interesting case, recorded by Lambron,[1] in relation to this subject, may be given. In a man sixty-nine years of age, a fish-bone had penetrated the head of the pancreas from the stomach, and had entered the anterior wall of the superior mesenteric vein obliquely from above downward and from before backward. It passed across the interior of the vessel, and was found lodged in its posterior thickened wall. The mesenteric vein at this point was filled with a grayish thrombus, which was continued into the portal vein and its hepatic branches, and was for the most part firm. The portal vein was narrowed, and its walls were thickened.

Mr. Markham[2] records a case in which hepatic abscess opened into the portal vein by ulceration. The opening was about an inch in length.

Laceration of the veins of the rectum may occur in two situations,—one beneath the mucous membrane, and the other between the muscular coats of the bowel. Laceration of the submucous veins, when situated near or at the Sphincter Ani, forms small circumscribed hæmatomata which by the practitioner are commonly designated *external hæmorrhoids*. A similar lesion of the intermuscular veins above the region of the Sphincter Ani causes diffuse clots to form in the walls of the rectum, which induce secondary degenerative changes in its coats, and predispose the rectum to various phases of diseased action, and even to rupture. E. Quénu[3] wrote an elaborate essay on the rare lesion last named, accompanied by an original observation and the study of seven recorded cases.

THE CARDIAC VEINS.

The Cardiac Veins, or the veins of the heart, receive blood from the walls of the heart, and convey it to the right auricle. They are without valves for the most part; near the mouth of the larger vessels one or two small unpaired valves may be seen.

They are three in number, as follows:—

Great Cardiac, or Coronary.
Posterior Cardiac.
Anterior Cardiac.

[1] For an admirable *résumé* of the symptoms of portal phlebitis, see W. C. Roberts, New York Journ. of Med., 1849, vol. ii. 318.

[2] Retzius, Allegemein. Med. Zeitung., Feb. 1834, 21.

[1] Gazette Méd. de Paris, 1842, 620.

[2] Trans. Path. Soc. Lond., iv. 1854, 165.

[3] Rev. de Chir., Mar. 1882, literature; see also abstract, N. Y. Med. Journ., 1882, vol. xxxvi. 550.

The Great Cardiac or Coronary Vein arises from the apex within the interventricular groove in front. It passes upward to the transverse groove and inclines to the left, between the left auricle and left ventricle, to reach the posterior surface of the heart, where it empties into the lower border of the right auricle near the interauricular septum. Within an inch of its termination it has received the name of the *coronary sinus* and is surrounded by muscular fibres. The vein receives blood from the anterior and posterior surfaces of the heart and from the septum between the ventricles. The right auriculo-ventricular groove is occupied by a small vein which empties into the coronary sinus.

The Posterior Cardiac Vein lies on the posterior surface of the heart within the interventricular groove, its radicles anastomosing freely with the preceding. It passes directly upward to join the great cardiac vein at the coronary sinus.

The Anterior Cardiac Veins are from five to six in number. They derive their blood from the walls of the right ventricle, and, uniting finally into two or three trunks, empty into the right auricle at the inferior border of the anterior wall. One of these veins is larger than the rest. Their orifices have been called the Thebesian foramina, although the same name has been given to minute depressions of the endocardium received within pockets on the auricular walls.

Through the minute network which surrounds the roots of the great arterial trunks, the cardiac veins are continuous in part with the diaphragmatic veins. Very rarely the great cardiac vein empties into the left innominate vein. J. W. Meckel records an instance in which the vein opened into the right auricle. The circular sinus, a small auricular vein, and a small oblique vein, *vestigial* vein, opening into it, are survivals of the fœtal left superior vena cava.

A DESCRIPTION OF THE FŒTAL CIRCULATION AS OBSERVED AT ABOUT THE SEVENTH MONTH OF DEVELOPMENT.

(Fig. 1, Plate LXIII.)

In many points of structure and relation, the fœtal heart and the great vessels in its immediate neighborhood differ from the same parts in the adult. Thus the auricles are proportionately more capacious, and, the right side of the heart being as robust as the left, the entire organ is relatively larger. The interauricular septum is defective, and presents at the lower and back part an opening called the foramen ovale, which is protected by a valve in the left auricle. Lying to the right side of the orifice of the inferior vena cava is an oblique ridge of membrane directed upward and to the left, called the Eustachian valve. Continuous with the pulmonary artery, and in the line of its trunk, is the *ductus arteriosus*, a short vessel which communicates with the aortic arch just beyond the origin of the great arteries of the head and neck.

These peculiarities are necessary in an organ which, while adapted to the necessities of an air-breathing creature, is temporarily in the position of the heart of an aquatic animal, or, to speak accurately, of an animal sustaining external respiration by means of a fluid medium. The placenta is the source of the respiratory interchange and of nourishment, the umbilical vein carrying the revivified blood to the fœtus, and the two umbilical arteries returning the blood to the placenta.

The umbilical vein passes along the edge of the suspensory ligament to the liver, and enters the longitudinal fissure of that organ, following it as far as the transverse fissure. It here divides into three or four branches, one inosculating with the portal vein (or, as represented in the figure, this may be said to be the branch to the right lobe which *receives* the portal vein), one going to the left lobe of the liver, one to the right lobe, another to the quadrate and Spigelian lobes, and a fourth which forms the *ductus venosus*, and which may be considered as the continuation of the main trunk, joining the inferior vena cava near the entrance of the hepatic vein. Dr. Jno. Reid[1] gives the umbilical vein a termination in the left branch of the portal vein. From this branch the ductus venosus arises as a distinct structure.

The blood of the inferior vena cava enters the right auricle. The current is directed by means of the Eustachian valve upward and inward to the foramen ovale, and through it to the left auricle, thence to the left ventricle, and, by way of the aorta, to the innominate, carotid, and subclavian arteries. It is a remarkable fact that all or nearly all of this blood goes directly to the head, neck, and superior extremities, notwithstanding the fact that no structural peculiarity in the aorta prevents its passage downward past the orifice of the *ductus arteriosus*.

The venous blood descending by the superior vena cava enters the right auricle, and is directed downward in front and to the right of the orifice of the inferior vena cava to the right ventricle, a small

[1] Edin. Med. and Surg. Journ., 1835, xliii. 310.

quantity of blood only being swept away into the current toward the foramen ovale. Thence it passes through the pulmonary artery to the *ductus arteriosus*, which lies in such a position as to be in the axial line of the main trunk of the pulmonary artery, and to cause the blood to be deflected along the descending aorta. The descending aorta divides into the right and left common iliac arteries, and, arising from the anterior aspects of the internal iliac arteries, are the large *hypogastric arteries*—one on either side of the body.[1] Through these the venous blood from the fœtus is returned to the placenta. Each ascends the anterior wall of the abdomen by the side of the bladder, and escapes at the umbilicus, after passing which orifice the two hypogastric arteries[2] become the umbilical arteries and twist together around the umbilical vein, to form with this vessel the vessels of the umbilical cord.

The umbilical arteries present a number of annulose constrictions, with intervening sinus-like expansions. In some examples the constriction between a pair of expansions is of a diameter admitting a small bristle only.[3]

Changes after birth.—The *ductus arteriosus* begins to close immediately after air has been received into the lung. By the third or fourth day, the flow of blood is materially interrupted, and by the eighth or tenth is entirely stopped. Within three weeks the canal is absolutely impervious. The foramen ovale is usually closed by the seventh or tenth day. It is not always so completely obliterated as is the ductus arteriosus, since a small persistent valvular opening can often be demonstrated even in the adult. The vascular connection between the iliac arteries and the umbilicus is obliterated from the second to the fifth day.

According to authorities collected by Dr. S. Smith,[4] the umbilical vein is patulous for two or three weeks after birth, and canals have been traced in it even at the sixth week.

The position of the hypogastric arteries can be detected in the adult subject by means of two converging folds of peritoneum, which start from the sides of the fundus of the bladder, to meet at the umbilicus. Between these is a median fold which indicates the site of the former urachus.

Remarks.—The foramen ovale is patulous, it is thought, in one in every five or six subjects. There need be no mixture of blood in either auricle from this cause, owing to the obliquity of the orifice to the plane of the fossa ovalis; though the opening *may* permit the over-distended right auricle to pour blood into the left.

The post-natal closure of both the foramen ovale and the ductus arteriosus is generally thought to be due to the effect upon the heart and the adjacent vessels of the blood returned from the lungs to the heart, aided by the action of muscular fibres derived from the fasciculi in the walls of the left auricle. To these Dr. W. S. Forbes[1] would add, in the instance of closure of the ductus arteriosus, the traction exerted by the descent of the Diaphragm upon the fibrous bands extending from the tendinous centre of this muscle to the aortic arch.

In newly-born infants, ligation of the umbilical vein, instead of producing a firm thrombus and obliterating the vessel, sometimes produces a soft puriform thrombus which extends into the portal vein.[2]

Cirrhosis of the liver often leads to a peculiar dilatation of the superficial veins about the umbilicus. This may give a dusky coloration to the integument at that point, or it may advance so far as to produce a varicose condition of the larger veins. In the latter variety it has been supposed that the umbilical vein has reopened, and that the circuit between the deep epigastric and the umbilical vein, usually characteristic of the fœtal circulation, is relieving the portal system. Sappey believes that the true explanation of such a condition of the superficial veins lies in the fact that a small vein accompanying the ligamentum teres becomes enlarged, the remnant of the umbilical vein remaining unchanged.

By umbilical hernia is meant a protrusion of some of the abdominal contents through an opening in the relaxed structures at the umbilicus or through the abdominal parietes in its immediate neighborhood.

[1] The hypogastric arteries, as described by some writers, arise from the common iliac arteries.

[2] In Plate LXIII., the words "umbilical artery" have unfortunately been engraved alongside of the hypogastric.

[3] J. C. Ewart, Journ. Anat. and Phys., 1878, 229; also Berger (Archiv. de Phys., 1872, 551).

[4] N. Y. Journ. of Med., 1855, xv. 73.

[1] Amer. Journ. of Med. Sci., 1880, lxxx. 88.

[2] Francis Delafield, a Hand-Book of Post-mortem Examinations, etc., 1872, 188.

THE LYMPHATIC SYSTEM.

General Considerations.

The Lymphatic System embraces an assemblage of structures designed to accommodate a colorless liquid containing corpuscles, termed lymph (see p. 90).

The following structures will be separately described:—

Lymphatic Vessels.
Lymphatic Glands.
Lymph-Spaces and Lacunæ.
Lymph-Interstices or Juice-Canals.

The larger *lymphatic vessels* are distributed throughout the body in association with the bloodvessels and nerves, while the smaller ones form coarse networks in the regions occupied by the capillaries of the blood-vessel system. The lymph-canals of the mesentery, from the fact that they convey the chyle from the small intestine to the thoracic duct, are sometimes called the *chylous vessels* or *lacteals*. In the intervals between the absorption of chyle, these vessels are filled with lymph.

The lymphatic vessels are more numerous in some parts of the body than in others. Thus, they are sparsely distributed on the outer sides of limbs, but are abundantly present upon the inner sides, and also at the lines of junction of the limbs with the trunk. They favor the tracts occupied by the arteries and veins, and are best developed in the thoracic and abdominal cavities. They are often disposed in a superficial and a deep set.

The lymphatic vessels are furnished for the most part with great numbers of valves, which are arranged after the manner of the valves of the veins. Nodule-like swellings of each lymph-vessel answer to the positions at which the valves are located. In many instances the valves are so numerous as to give to the vessel the appearance of a string of beads.

Since the valves both of the lymphatic vessels and of the systemic veins are directed toward the heart, the lines of inflammatory invasion in both sets of vessels pass from the peripheral toward the cardiac extremities. When the lymphatic vessels are obstructed, they may become enlarged to an extent unknown to the veins.

The *lymphatic glands* are round or elliptical flat solid bodies developed about the walls of the lymph-vessels and traversed by minute lymph-canals. The lymph-vessels approaching the gland are said to be *afferent*, and those leaving the gland *efferent*.—The afferent vessels divide into two or more branches before entering a gland; the efferent, while fewer in number than the afferent, are often of larger size. A group of lymphatic glands with their associated vessels is called a *plexus*. It follows that, in a system of lymphatic glands with their plexuses, a group of efferent vessels of a distally placed gland may be the afferent vessels of the next proximal group. Lymphatic glands are more numerous in the thorax and in the abdomen than in the head and the neck; they are sparsely distributed in the limbs and at the regions of the groin and the axilla, and are absent within the brain-case. Lymphatic glands are, as a rule, so disposed as to exert, in their normal condition, no pressure upon adjacent parts. In the limbs, the more deeply seated glands lie along the course of the arteries, and the more superficial glands along the course of the veins.

Diseased action very rarely, if ever, originates in the lymphatic glands. As a result of secondary causes, especially from transmitted irritative influences, the glands frequently become the seat of hyperplasia, which will often persist after the original irritation has ceased to exist. In illustration of this tendency it may be said that in syphilis the lymphatic glands of the groin remain engorged long after the chancre has disappeared.

By *lymph-spaces* and *lymph-lacunæ* are meant those irregularly shaped spaces of varying size which are lodged about important viscera or around the larger bloodvessels and nerves of the head and trunk. In the former instance they constitute the great *serous chambers*, namely, the pericardium, the pleuræ, the peritoneum, the tunica vaginalis testis, and the arachnoid sac. In the latter instance they form the *perivascular sheaths* of the arteries of the pia mater, and the *perineural sheaths* of the optic, auditory, and other nerves.

The lymphatic fluid, notably in the lymph-spaces, has considerable mechanical use. The brain may be said to be floated in part within the sub-arachnoid lymph-space, and the dangers arising from pressure

against the arteries of the base of the brain are thereby in a measure averted. (See Membranes of the Brain.) The spinal cord is aided in resisting concussion and in sustaining a central position in the vertebral canal by a similar arrangement. Perivascular spaces must in like manner facilitate the dilatation and contraction of the vessels, and aid in resisting injurious compression from adjacent parts. Lymph spaces are thought to convey the lymph from the tissues formerly described as without lymphatics. Among these may be mentioned the central nervous system, the eyeball, the labyrinth of the ear, and the placenta and its membranes.

The perineural lymph-space about the optic nerve communicates freely with the subarachnoid lymph-space. Disease of the eye associated with central lesion, especially with pressure upon the base of the brain, interferes with the flow of the lymph from the orbit to the interior of the skull, thus causing secondary lesions in the eye which are easily recognized by the ophthalmologist.[1]

The *lymph-interstices* or *juice-canals* are the beginnings of the lymphatic system. They serve to distribute a nutritive fluid in and among the ultimate elements of the tissues. In common parlance, a tissue is said to be *vascular* only when it is occupied by blood capillaries. In a more exact sense, all tissues are vascular, since the juice-canals can be demonstrated penetrating them. In some tissues, such as those of the cornea, and the epithelial structures generally, no blood-capillaries exist, and in some others, as cartilage, there are few or none. Such structures are sustained entirely by the lymph flowing through the juice-canals. The beginnings of the lymphatic vessels are better defined in the walls of the small intestine than in those localities where they lead from large and irregular lymph-spaces.

The lymph is propelled forward by the movement of muscular and other masses adjacent to the spaces and vessels as well as by the muscular fibres in the walls of the larger trunks. The act is aided in some animals, as batrachians and birds, by muscular chambers (lymphatic hearts) moving rhythmically.

Remarks.—Diseases in which dilatation and obstruction of the lymphatic vessels occur, are either local, and are the effects limited to the afferent vessels of a single group of glands, or they are general and involve the entire lymphatic system. The diseases of the latter group are apt to be associated with morbid action of the appendages of the bloodvessel system. The colorless corpuscles of the blood are increased in number, the heart is hypertrophied, and the disposition to cancerous and tubercular disease pronounced.

The lymphatic system has important clinical relations with the spleen, the tonsil, and the adenoid bodies of the base of the tongue and the roof of the pharynx. Together with other ductless glands, these structures assist in adding white blood-corpuscles to the blood-stream. They are most active at the period between the disappearance of the thymus body and the completion of the medullary spaces of the long bones. This period practically includes infancy and adolescence. The practitioner notes that during this time the tonsils, the adenoid bodies of the pharynx, and the lymphatic glands of the neck and chest are more frequently enlarged than at any subsequent period.—Strumous, cancerous, and syphilitic disease are all prone to cause engorgement and hypertrophy of the lymphatic glands.

Dr. Stephen Smith[1] calls attention to a danger attending the use of Esmarch's bandage in cases where septic matter exists in the tissues. He reports a case of fatal diffuse cellulitis which was supposed to have had its origin in the enforced transit of peccant matter upward along the larger vessels from the lymph-spaces lodged with the area which had been compressed by the bandage.

For clinical purposes, the following table may prove of use in tracing the source of any inflammation, dilatation, or other change in the character of the normal lymphatic vessels or glands.

A CLINICAL TABLE OF THE LYMPH-STREAMS.

Lymph-streams pouring into the venous stream at the right subclavian vein.	Those of the right side of the head. Those of the right side of the neck. Those of the right side of the upper extremity. Those of the right thoracic wall and, in part, of the liver. Those of the right lung. Those of the right side of the heart.

[1] W. F. Norris, Trans. Amer. Ophthalmolog. Soc. 1874, 163; and Phila. Med. Times, 1879, ix. 565. For detailed accounts of the large lymph-spaces and lacunæ, see the organs about which they are lodged.

[1] Archives of Clin. Surg. 1877, ii. 70.

Lymph-streams pouring into the venous stream at the left subclavian vein.

- Those of the left side of the head and neck.
- Those of the left upper extremity.
- Those of the inferior extremities.
- Those of the pelvic and abdominal organs (in part only of the liver).
- Those of the external genitals.
- Those of the left thoracic wall.
- Those of the left lung.
- Those of the left side of the heart.

Of all classifications of lymphatic vessels the one just presented is the most inviting; but, inasmuch as such a grouping would demand a separate description of the lymphatics on the right and left sides of the head, the neck, the upper extremities, the thoracic wall and thoracic contents, it has been thought best to retain the regional classification which is herewith given.

A CLASSIFICATION OF THE LYMPHATIC VESSELS.

The lymphatics of the body are arranged for *topographical purposes* as follows:—

I. Lymphatics of the Head and Neck.
II. " " Upper Extremity, including the Right Lymphatic Duct.
III. " " Lower Extremity, the Pelvis, and the External Genitals.
IV. " " Abdomen, including the Left Thoracic Duct.
V. " " Thorax.

I. The Lymphatics of the Head and Neck.

The lymphatic vessels of the face lie for the most part along the junction of the cheek with the nose. They are received here from the central portions of the forehead, and pass downward over the face, and thence into the submaxillary lymphatic glands.

The Lymphatic Glands of the head and neck are disposed in the following order:—

First, a group of small glands, two to three in number, lie upon the parotid gland in front of the external auditory meatus. It is exceptional to find glands upon the face above the line of the mouth. Infrequently a small one is seen at the side of the root of the nose, and another about the size of a pea may be sometimes recognized below the symphysis, in cases of syphilis. Velpeau is of the opinion that the median parts of the forehead and eyebrow are drained by a set of vessels distinct from those belonging to the lateral portion. The natural deduction from these premises is that morbid processes excited in the region of the temple would be apt to involve the lymphatic glands at the angle of the jaw, while diseased action in the median portion of the forehead would involve the glands lying about the chin and the suprahyoid space.

Second, a group of three or four is placed behind the auricle at the insertion of the Sterno-Cleido-Mastoideus.

Both the first and second group derive their afferent vessels from the external soft parts of the skull.

Third, a group of deep facial glands, six to eight in number, lies in the spheno-maxillary space, and upon the lateral wall of the pharynx. These glands collect the lymph from the orbit, the nasal cavities, the pharynx, and the parts about the spheno-maxillary space. According to Arnold, a number of the lymphatics of the brain-case join this series through the oval and spinous foramina of the sphenoid bone.

Fourth, a group of the submaxillary glands is situated superficially beneath the horizontal ramus of the lower jaw, is covered in by the superficial layer of the fascia. One of the largest of this group overlies the submaxillary salivary gland. These glands receive from the superficies of the face the lymph which is conducted downward along the course of the anterior facial vein. Other vessels are received from the tongue and the base of the mouth.

EXPLANATION OF PLATE LXXVI.

Fig. 1. The superficial lymphatics of the head and neck.

Fig. 2. The deep lymphatics of the head and neck, together with the lymphatics of the side of the thorax and the heart. The tributary to the internal jugular vein must be considered anomalous. The transverse vessel is a large submental vein, continuous with the external jugular, which joins the internal jugular.

Fig 1.





PLATE LXXVI

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Fifth, a group of superficial cervical glands lies upon the lateral parts of the neck, in front of and upon the Sterno-Cleido-Mastoideus and below the parotid gland. They receive superficial lymphatic vessels both from behind and in front. Small glands are often seen in the middle of the neck, lying on the Sterno-Hyoid muscles, but rarely on the Platysma Myoides.

Sixth, a set of deep lymphatics accompanies the course of the internal carotid and the common carotid arteries. They receive vessels from the brain-case through the posterior lacerated foramen, from the pharynx, the tongue, the larynx, and the thyroid body. The glands at the base of the neck have received the name of the supra-clavicular glands. In addition to those from adjacent parts, these receive vessels from the vertebral canal.

Remarks.—The superficial gland at the angle of the jaw is frequently enlarged in pharyngitis. Enlargement of the gland over the submaxillary salivary gland may be mistaken for disease of the latter structure. It is easy to distinguish the two conditions by the fact that the salivary gland is fixed, while the lymphatic gland is movable. In cancerous involvement, however, this gland soon becomes fixed to the lower jaw.

Allan Burns[1] invites attention to the liability of the lobulated edges of a bronchocele being mistaken for enlarged lymphatic glands.—Enlargement of lymphatic glands at the base of the neck is of exceptional interest apart from the importance of anatomical relations. Paget alludes to the importance of the enlargement of the glands in old persons who are the subjects of cancer and scrofula.[2]

The cervical glands are capable of assuming enormous proportions in strumous subjects, and may act as exciting causes of dyspnœa and dysphagia, either by direct pressure upon the trachea and the œsophagus or by interference with the pneumogastric nerve.

The removal of enlarged cervical glands which are found to maintain injurious pressure should never be inconsiderately undertaken. The following statements will have practical interest in connection with this subject.

The lymphatic glands along the course of the internal jugular vein have been known to excite ulceration of the walls of the vein, and to cause death by subsequent losses of blood. After operation for their removal the vein may ulcerate, as it lies in the wound of incision. Suppuration excited in or about the glands may involve the common carotid (see p. 356) and the internal carotid arteries (see p. 366). D. W. Cheever,[1] in removing a large lymphatic tumor from the basal portion of the neck, probably wounded the thoracic duct and the subclavian vein. Death followed in thirty-six hours.

An attempt, reported by Moxon, to remove a cancerous lymphatic gland of the neck excited œdema of the glottis. Death ensued within twenty-four hours.[2]—In the case of a girl of thirteen years, a cervical lymphatic gland, the seat of sarcomatous deposit, was found by the same writer[3] to occlude the internal jugular vein, and to cause death by the extension of inflammation to the pleura of the corresponding side.—The lymphatic glands at the nape of the neck are frequently found engorged in syphilis and in various forms of disease of the scalp.—For other comments on the cervical lymphatic glands, see pp. 261, 264, and 366.

II. The Lymphatics of the Upper Extremities and the Thoracic Wall.

Under this head are embraced—

(*a*) The Lymphatics of both Upper Extremities and the adjacent portions of the Thoracic Wall.

(*b*) The Right Lymphatic Duct.

(*a*) The lymphatics of the upper extremity and the adjacent portion of the thoracic wall converge toward the axilla, in the abundant connective tissue of which from eight to ten glands are situated. Small isolated glands are here and there seen, as at the inferior border of the Pectoralis Major, and in the interval between the same muscle and the Deltoid.

The lymphatic vessels of the arm accompany the superficial and deep veins. The superficial set collect the vessels from the fingers in a palmar arch, which, together with others from the inner border of the palm, ascend the arm. They are more numerous on the inner than on the outer side of the arm. One or two glands are found near the elbow, viz., at the position of the basilic vein a short distance above the internal condyle. The lymphatic vessels on the back of the hand and forearm gradually join the preceding by winding around the margins of the forearm, notably the ulnar. The deep lymphatics of the hand are much less numerous than the superficial, which they join at the carpus. They extend in the direction of

[1] Surgical Anatomy of Neck, 225.

[2] St. Bartholomew's Hosp. Rep., iii. 412.

[1] Boston Med. and Surg. Journ. 1875, N. S., xv. 424.

[2] Trans. Path. Soc. Lond. 1869, xx. 369.

[3] Ibid. 1869, xx. 400.

the deep veins. From two to five glands are found in the forearm, and one to two in the arm.

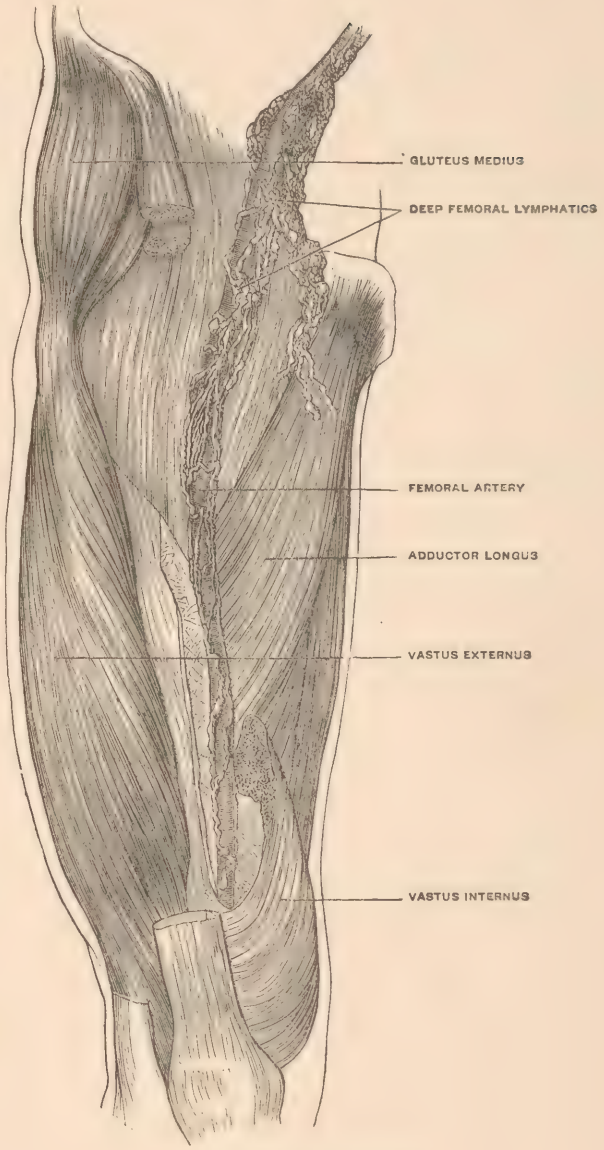
The lymphatics of the chest are superficial and deep. The superficial lie in the interval between the Pectoralis Major and Deltoid muscles, and also along the inferior border of the former muscle. With this set of vessels may be included a small gland lying in the epigastric region. These lymphatics anastomose with the deep set, with the lymphatics about the umbilicus, and with those coming thence to the inguinal regions.—A separate set of vessels drains the dorsal surface of the liver. The deep lymphatics follow the thoracic veins, and receive the vessels from the mammæ, anastomosing with the intercostal lymphatics. They receive some filaments from the internal thoracic lymphatics. The lymphatic vessels of the back converge to the shoulder from the neck, back, and loins. The superficial vessels wind round the borders of the superficial muscles to join the deep vessels, which lie for the most part along the line of the axillary artery. Rosary-like dilatations are occasionally met with about the elbow. The lymphatic gland above the elbow is often enlarged in secondary syphilis, as are those in the axilla in cancer of the mammary gland.

(*b*) The Right Lymphatic Duct is much shorter than the thoracic duct, measuring but an inch in length. It receives the lymphatic vessels from the right side of the thorax, the right lung, the right side of the heart, a part of the Diaphragm, the right superior extremity, the right side of the head and neck, and a portion of the upper surface of the liver. It joins the venous system at the angle between the right subclavian and the right jugular veins.

III. The Lymphatics of the Inferior Extremities and of the Pelvis.

The lymphatics of the inferior extremity comprise, like those of the superior extremity, a superficial and a deep set.—The *superficial* set arise in part from the dorsum and sole of the foot, towards its inner side, and follow the course of the long saphenous vein. Others ascend from the back and sole, and pass along the posterior or short saphenous vein. The vessels are most numerous along the inner side of the thigh, toward which the outer vessels converge in the neighborhood of the knee, and finally terminate above at the groin in the superficial lymphatic glands. Some of the vessels, however, terminate in a set of glands, lodged deeply in the popliteal space —the popliteal lymphatic glands—which are four or

Fig. 88.

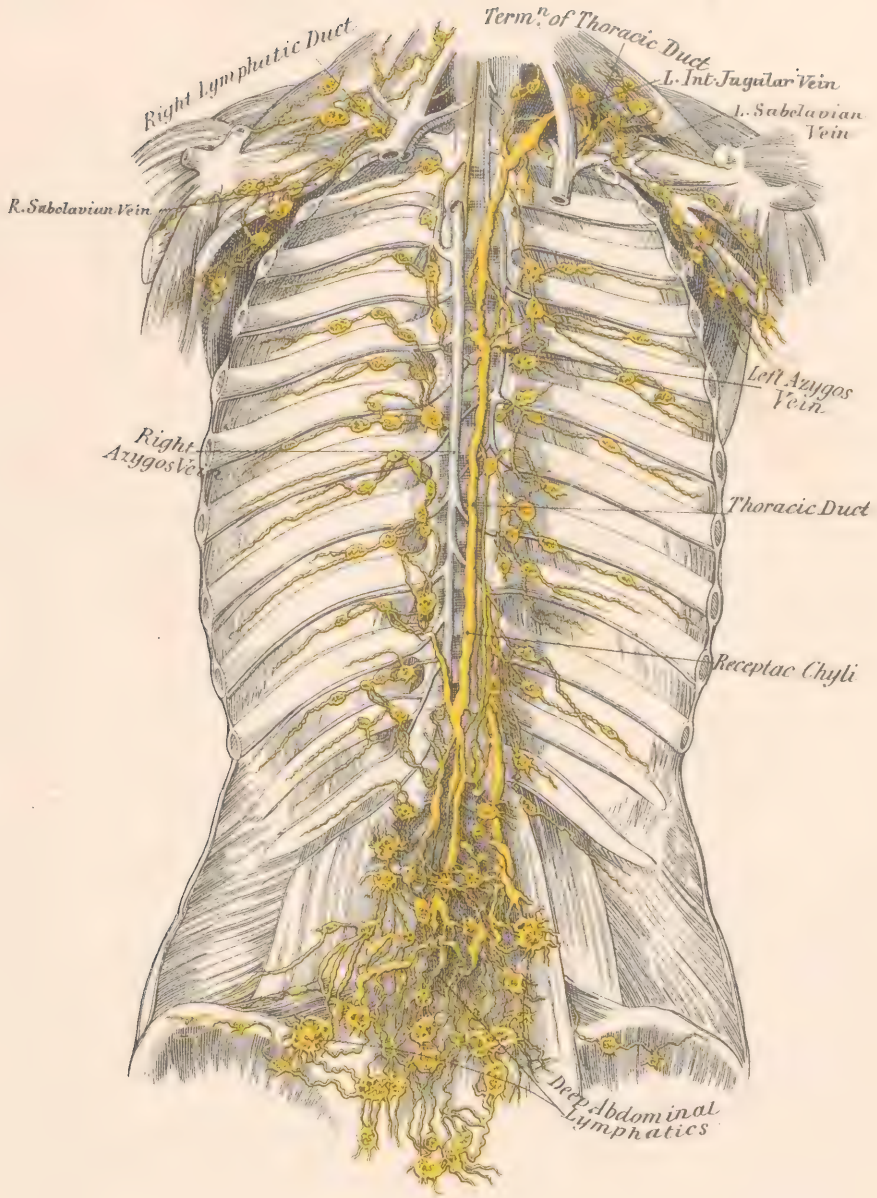


Lymphatics of the Thigh.

EXPLANATION OF PLATE LXXVII.

The lymphatics of the trunk, including the thoracic duct. For Left Azygos Vein, read left intercostal vein.

The leader to Receptaculum Chyli is placed three lines too high.



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five in number, and surround the artery of the same name.—The *deep* lymphatics are relatively few. Many of them end in the popliteal glands.

The lymphatics of the hypogastric region drain the region in which they are located, and anastomose with the epigastric lymphatics. They terminate in the superficial lymphatic glands.

The lymphatics of the inner side of the thigh and the gluteal region pass into the pelvis through the openings by which the obturator and sciatic arteries escape. They join the vessels situated about the internal iliac artery.

The lymphatic vessels of the external genitals form a superficial and a deep set. The superficial set consists of a group of three vessels, one on either side and one on the dorsum of the penis. In the female, analogous vessels are found upon the clitoris, passing thence upward through the mons veneris. The superficial vessels are received by the inguinal lymphatics. The deep vessels pass into the pelvis along the course of the internal iliac artery. The lymphatics from the scrotum and the labia majora pass upward and outward along the course of the external pudic arteries.

The superficial lymphatic glands vary from six to twelve in number, and are divided into an oblique and a vertical set. The glands of the oblique set are situated along the line of Poupart's ligament. The vertical set are arranged about the terminal portion of the long saphenous vein. The position of the saphenous opening is occupied by a gland, which sends branches of communication downward through the opening to join the deep lymphatics.

The deep lymphatic glands are from two to three in number, and are located upon the femoral artery and vein.

A small gland is sometimes found on the interosseous membrane at about the middle of the leg.

Remarks.—The application of a knowledge of the lymphatics of the lower extremity embraces the following considerations:—

(*a*) The lymphatic vessels may be inflamed without involvement of the veins, when the course of some of the main vessels can be distinctly traced under the skin. When chronically inflamed, and obstruction exists at the nearest lymphatic gland, the vessels may become thickened, dilated, and tortuous. The lymphatic vessels of the sheath of the penis are, perhaps, more frequently involved in diseased action than those of any other portion of the skin surface. Inflamed lymphatic vessels often coexist with a chancre. In cases of neglected chancre, associated with an indurated condition of the lymphatic glands of the groin, they may even form bulla-like swellings which sometimes rupture and permit the lymph to escape externally. Rarely dilatation of the lymphatic vessels occurs without apparent cause.

(*b*) The lymphatic vessels and the peri-vascular lymph-spaces are involved in elephantiasis.

(*c*) The lymphatic vessels may, from causes imperfectly understood, become filled with chylous fluid. In a case reported by Petters,[1] remarkable dilatation of the lymphatics existed in the right groin and in the abdomen, in a patient the subject of valvular heart disease. The glands were converted into cyst-like cavities filled with a yellow fluid. Rosary-like dilatations, similar to those seen at the elbow, occur infrequently below the groin.

T. Carr Jackson[2] describes a case of dilatation of the femoral lymphatics, which occurred in a lad of seventeen. The vessels burst externally.

(*d*) The lymphatic glands in the popliteal space may be confounded with bursal sacs communicating with the knee-joint. The glands can be distinguished from such sacs by the fact that they are the more deeply situated, and are nearer the median line. They may, when enlarged, give the impression that the popliteal artery is the seat of an aneurismal swelling.

The inguinal lymphatic glands are the common seat of diseased action dependent upon the transmission of the virus of syphilis, or of any other irritation whose point of entrance is through the external genitals. They frequently suppurate or excite suppurative cellulitis in the parts about them. Acute inflammatory engorgement of one of them has been known to induce fatal peritonitis by direct continuity through the lymphatic vessels of the abdominal wall.[3]

IV. The Lymphatics of the Abdomen.

The Lymphatics of the Abdomen include—

The Lymphatics of the Viscera and of the Abdominal Walls.

The Thoracic Duct.

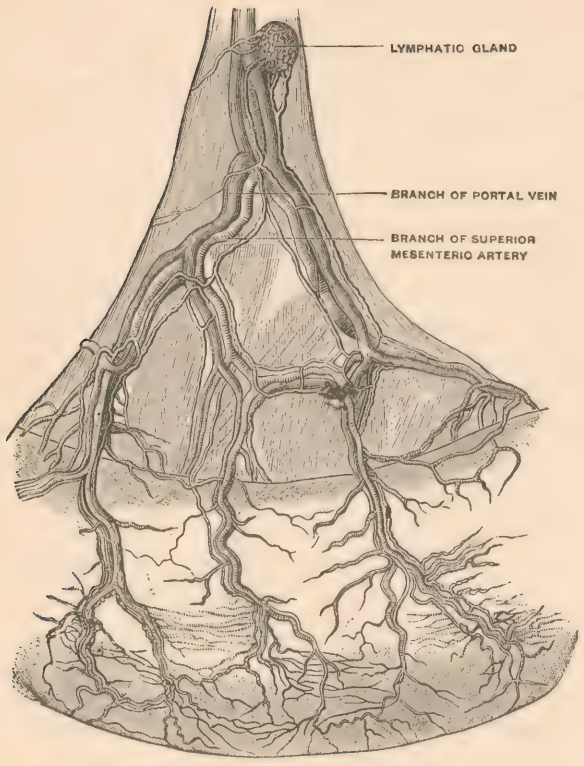
The Lymphatics of the Viscera and of the Abdominal Walls are contributory to the thoracic duct in great part, and are arranged in groups as follows:—

[1] Prag. Vierteljahrsschrift, 1861, lxxii.; also Schmidt's Jahrbücher, cxv. 183.

[2] Trans. Path. Soc. Lond. 1866, xvii. 287.

[3] F. Lente, New York Jour. of Med., 1850, 169.

Fig. 89.



Lymphatics of the Small Intestine and the Mesentery.

The lumbar plexus. This is situated in the lumbar region, and receives lymphatics from the Quadratus Lumborum and Psoas muscles, and from the vertebral column. To it converge lymphatics along the course of the external iliac artery, of the remains of the hypogastric artery, as well as the vessels from the internal organs of generation, the kidneys, and the suprarenal capsules, the lateral walls of the abdomen, and, on the left side, those from the sigmoid flexure and the rectum.

The cœliac group of glands. This is not sharply separated from the preceding. It surrounds the aorta, the cœliac axis, and the superior mesenteric artery, as well as the portal vein; extends behind the head of the pancreas, and is composed of from sixteen to twenty glands which receive lymphatics from the stomach, small intestine, large intestine, spleen and pancreas, and from the liver.

The gastric group. From the stomach proceed three groups of vessels—from the left, the upper, and the lower surfaces respectively. The lymphatics of the left group accompany the vasa brevia, and are in association with the lymphatics of the spleen. The vessels of the upper group lie within the folds of the gastro-hepatic omentum, in company with the coronary vessels. Those of the lower group lie upon the greater curvature in company with the right gastro-epiploic vessels. Some of the lymphatic vessels lie beneath the peritoneal coat, while others lie between the muscular and mucous coats.

The lymphatic vessels from the small intestine, here called the lacteals, lie between the two layers of the mesentery. Hence, the glands which accompany them are called the *mesenteric glands.* Each gland presents an average length of six to seven lines, and is four to five lines in width. Three rows of these glands are recognized: the first, nearest the intestine, is composed of small and widely dispersed glands; the second are somewhat larger and more approximate; while the third row lies at the root of the mesentery. The entire number of glands is estimated to range from one hundred and thirty to one hundred and fifty. They are more numerous toward the upper portion of the mesentery than at the lower. The minute lymphatics within the walls of the intestine are arranged as in the stomach, viz., one layer beneath the peritoneum, the other between the muscular and mucous coats. The former are arranged along the axis of the intestine, the latter transversely. Several small lymphatic glands are seen lying in the fold of peritoneum at the lower border of the spleen.

The lymphatics of the large intestine. These closely resemble those of the small intestine. The glands, however, are smaller, fewer in number, and are arranged in one or two rows. Those from the sigmoid flexure and rectum are directed to the left lumbar plexus; the remaining ones join the cœliac plexus, either directly or indirectly through the last row of mesenteric glands.

The lymphatics of the spleen and the pancreas. These follow the course of the splenic veins, and join the upper cœliac glands.

The lymphatics of the liver. The lymphatics are here superficial and deep. The *superficial* lie on the convex surface of the liver, in great part, and form a lateral and a median network on the right lobe, and, passing within the suspensory ligament of the liver, finally join the internal mammary plexus, as already described. But others, namely, those situated over the left lobe, in part, pursue a different course. These are collected upon the left lateral ligament of the liver, and enter the upper part of the cœliac group in company with the lymphatics from the spleen and the pancreas. Hyrtl mentions a third group of vessels from the posterior border of the right lobe, which join the posterior mediastinal glands. The superficial vessels of the concave surface join the deep at the transverse fissure.—The *deep* lymphatics enter the transverse fissure with the portal vein. As

already seen, they unite with the superficial, and, after joining those of the stomach, they are received into the cœliac group of glands. The glands that are seen along the interval between the liver and the cœliac region are called the hepatic glands.

Remarks.—According to Murchison,[1] an enlarged lymphatic gland lying in the transverse fissure of the liver is apt to press against the common bile-duct and the portal vein. Such pressure is often seen in cancerous and waxy changes in the liver.—Retro-peritoneal lymphatic glands may assume enormous proportions, especially when cancerous or tuberculous. When such masses project forward, they may surround the pyloric end of the stomach, and compress the common bile-duct. When they project to one side, they may involve the inferior vena cava and the aorta. In aneurism of the aorta, the glands may become imbedded in the walls of the vessel, and in this way form part of the surface of the morbid mass.[2]

The Thoracic Duct (left lymph-trunk) receives the lymph from the intestine (both from the villi and the coats of the bowel) and the greater portion of its appendages, from the kidney, the parietes of the abdomen, the lower extremities, the right lung, and the right side of the heart. That portion of the dorsal surface of the liver pertaining to the right lobe is drained by the right thoracic duct.

The duct is formed by the union of three vessels: a right and a left branch from the lumbar plexuses, and a central branch from the intestine. The point of confluence is situated in front of the second and third dorsal vertebræ. The thoracic duct extends thence upward along the vertebral column, either behind or to the right of the aorta, enters the aortic orifice of the Diaphragm, and, lying in the space between the aorta and the azygos vein, keeps to the right side as far as the fourth dorsal vertebra, where it crosses obliquely to the left of the vertebral column over the azygos vein, and ascends along the median border of the ascending portion of the vertebral artery to the base of the neck. From its deep position at the level of the seventh cervical vertebra, it curves forward, downward, and outward at the inner border of the Scalenus Medius, over the apex of the pleura, and terminates at the angle of junction of the subclavian and internal jugular veins of the left side.

The duct is from fifteen to eighteen inches in length, and has an average diameter of two lines. At its origin it is dilated into an irregularly triangular figure termed the *receptaculum chyli* (reservoir of Pecquet); at its termination the duct is again slightly expanded. Its outlet into the subclavian vein is guarded by a distinct valve.

Variations.—The thoracic duct sometimes empties into the jugular, the azygos, or the left innominate vein. As an exceedingly infrequent occurrence, the duct may be double, or even multiple, as many as six separate terminal vessels being present, which are received into the subclavian, internal jugular, vertebral, and axillary veins. From five to twelve vessels may converge to form the *receptaculum*.[1] Associated with transposition of the viscera, the right and left ducts may be transposed; but they may be thus arranged independently of mal-arrangement of other parts. The duct may be deflected by an exostosis, or obliterated, when a collateral trunk, running up along the right side of the vertebral column, may be established.[2] In addition to the thoracic duct, and, in a measure, taking its place, lymph-vessels may be found opening into the renal veins, the inferior vena cava, the portal, and the azygos and the hemi-azygos veins.

Remarks.—The thoracic duct, as it passes through the chest, may be pressed upon and obliterated by tumors, or by a hypertrophied heart. In cases of chylous dropsy, or other diseases associated with obstruction of the lymph-return, the thoracic organs should be carefully examined. In like manner, all conditions which maintain states of distension of the large veins of the neck and thorax should be studied in connection with the lymph-return, for the difficulties attending such return must be thus inevitably increased. Thrombosis of the left internal jugular vein at its junction with the subclavian vein or of the left subclavian vein will obstruct the lymph-return from the thoracic duct. A case of obstruction of the thoracic duct at the point of its junction with the subclavian vein, with subsequent perforation of the *receptaculum chyli* and infiltration of neighboring lymphatic glands, is described by W. Cayley.[3]

The pus of a psoas abscess may pass into a radicle of the thoracic duct, and similar invasions may ensue upon inflammatory and gangrenous states of the mesentery. In chylous dropsy, a disease characterized by the presence of a chyle-like liquid in the peritoneal cavity, it is assumed that sufficient pressure has been exerted against the thoracic duct, at or near its origin, or upon the chyle-bearing vessels of the

[1] Diseases of the Liver, 340.

[2] T. Thurnam, Med.-Chir. Trans. 1840, xiii. 334.

[1] For anomalies of the lymphatic system, see G. Breschet, Le Système Lymphatique, Paris, 1836, 238.

[2] W. Krause. Henle's Anatomie.

[3] Trans. Path. Soc. London, 1866, xvii. 163.

mesentery, to force the chyle back through the lymph-spaces of the peritoneum or central tendon of the Diaphragm, and thence into the cavity of the peritoneum. Under these circumstances the superficial lymphatic vessels at the umbilicus may be distended. The following interesting case of probable rupture of the thoracic duct within the chest is reported by Quincke:[1] A man, aged fifty, was run over by a wagon, and incurred fracture of the seventh and ninth ribs on the right side. Chylous empyema followed, while the lymphatic vessels of the right side of the trunk and of the thigh were dilated. At the autopsy, the thoracic duct at the base of the neck was found obliterated by a clot, while in the chest the course of the duct was lost in the products of inflammation about the right pleural sac.

In some cases of morbid growth in the testis, the lymphatic vessels passing thence to the abdomen have been found enormously enlarged.[2]

In a case reported by Prof. D. Hayes Agnew,[3] the thoracic duct was found compressed by a cancerous growth originating in the pancreas.

In rare instances the thoracic duct is found greatly enlarged and contorted without apparent cause.

V. The Lymphatics of the Thoracic Cavity.

The Lymphatics of the Thoracic Cavity comprise the following:—

The *intercostals*, which accompany the intercostal veins. They are derived from the lateral abdominal and thoracic walls, the pleura, the Diaphragm, the dorsal muscles, and the vertebral column, and are associated with the intercostal glands, which vary from sixteen to twenty in number, and lie on either side of the spine in the neighborhood of the heads of the ribs.

The *posterior mediastinal* lymph-vessels, which arise from the posterior wall of the pericardium, the œsophagus, and the walls of the posterior mediastinum. The glands are from eight to twelve in number. Their efferent vessels on the right side empty into the thoracic duct, but on the left join the bronchial glands. Quain states that in the œsophagus the lymphatics lie in a single layer, internal to the muscular layer.

The *internal mammary* lymphatics, so called from their relation to the internal mammary veins, originate from the abdominal wall in the epigastric region, and receive the vessels from the upper surface of the liver in part, and from adjacent parts of the intercostal spaces. From six to eight sternal glands lie behind the sternum.

The *lymphatics from the pericardium*, and in part from the great vessels and the thymus, pass into a group of glands, ten to twelve in number, lying at the base of the pericardium, and at the origin of the aorta. These, together with the internal mammary lymphatics, join the right thoracic duct on the right side; while those of the left join the left thoracic duct.

The *pulmonary* lymphatics are superficial and deep. They unite at the root of the lung, and enter, for the most part, the bronchial glands, which are from ten to fifteen in number on each side. The largest of these occupy the interval between the right and left bronchus; the remainder are lodged chiefly in the angles of divergence of the smaller tubes. The vessels on the left side empty into the thoracic duct, and those of the right side join those of the posterior mediastinum in entering the right thoracic duct.

Remarks.—The bronchial lymphatic glands may, when engorged, compress the bronchial tubes at their origin, or the trachea immediately above. Golding Bird[1] reports a case in which death was attributed to such pressure.

An enlarged bronchial gland may be associated with disease in the œsophagus, as occurred in a case reported by O. Ward,[2] in which the œsophagus was dilated opposite the bifurcation of the trachea, at which point a longitudinal ulcer was seen one and a half inches long, communicating with an enlarged and suppurating bronchial gland, which filled up the interval between the bronchial tubes. In another case,

[1] Deutsche Archiv für klin. Medecin, 1875, ii. 121.

[2] For case and elaborate figure of dilatation of the thoracic duct, see G. Breschet, loc. cit., 286, plate 3.

[3] Trans. Path. Soc. Phila. 1858, i. 8.

[1] London Medical Gazette, 1843, N. S. i. 218; also Amer. Journ. Med. Sci. 1843, vi. 209.

[2] Trans. Path. Soc. Lond., ii. 208.

EXPLANATION OF PLATE LXXVIII.

Fig. 1. The veins and lymphatics of the upper extremity.

Fig. 2. The veins and lymphatics of the foot and the leg.

Fig. 3. The veins and lymphatics of the upper portion of the leg, the thigh, and the external genitals.

Fig 1

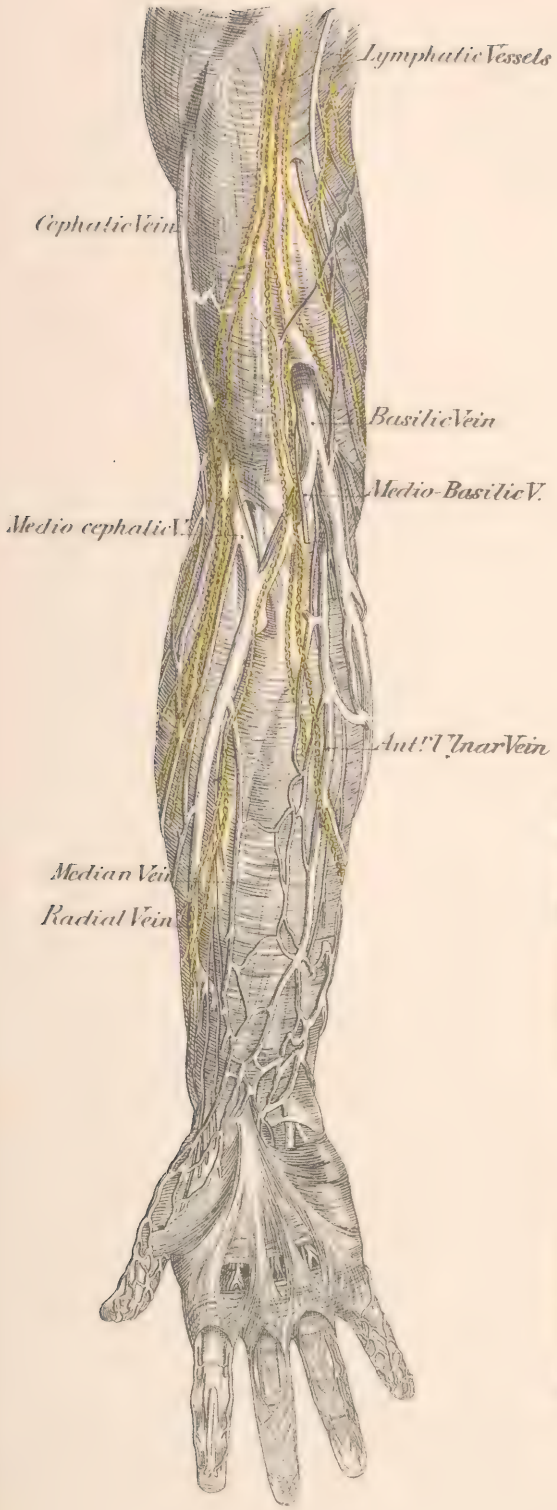


Fig 2

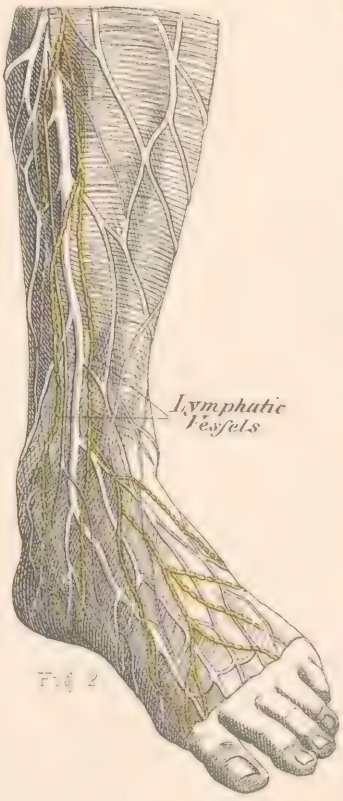
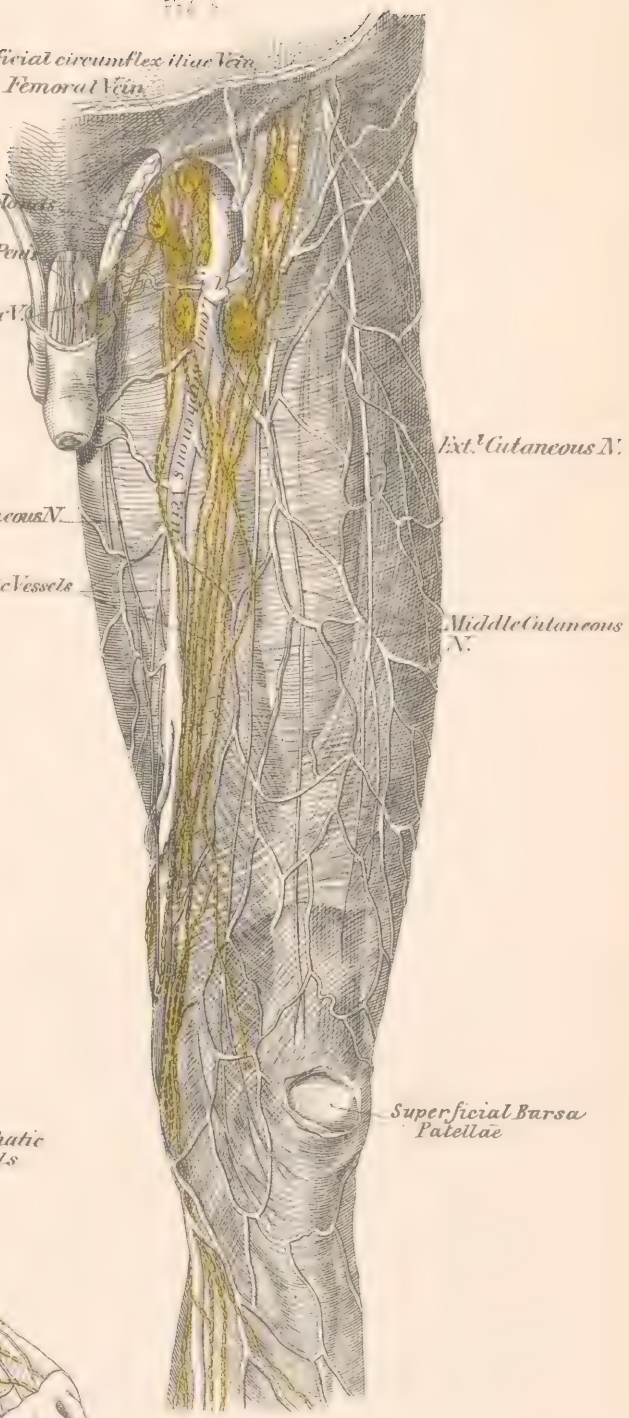


Fig 3



T. Sinclair & Son Lith.

reported by Dr. Lewis,[1] a stricture of the œsophagus was associated with engorgement of the bronchial lymphatics.

The presence of enlarged bronchial glands can be diagnosed during life, according to B. Yeo,[2] who finds that the position occupied by them corresponds to an area of dulness situated below the level of the fourth dorsal vertebra.

The pressure of the glands may induce tracheal stenosis, and even perforation of the trachea. This lesion was detected by Sidney Copeland,[3] who found, in a boy four years of age, scrofulous degeneration of these glands, followed by occlusion of the trachea just above the point of bifurcation. The aperture in the trachea permitted the entrance of the diseased gland, and measured nearly half an inch along the axis of the tube, while for more than an equal distance above the calibre of the trachea was narrowed by the pressure of the gland from without.

The bronchial lymphatic glands may aid the left bronchus in making injurious pressure against the œsophagus (see Trachea).

THE DUCTLESS GLANDS.

The Ductless Glands are special vascular structures found in the head, neck, and trunk. They include the pituitary, the thyroid, the intercarotic, the thymus, and the coccygeal bodies; the adenoid structures of the alimentary canal; the spleen, and the suprarenal capsules. The place these structures should occupy in an anatomical system is subject to dispute. From the data furnished by embryology, the spleen, the solitary and agminated bodies of the small intestine, the tonsil, and other adenoid structures of the alimentary canal, are shown to be closely related to the lymphatic system, while the pituitary body, in part, the thyroid body, the thymus body, the intercarotic body, and the coccygeal body are developed from the hypoblast of the embryo in association with the primitive alimentary tract, and, while presenting some features in common with the lymphatic system, form a distinct group.

The suprarenal capsules, the intercarotic body, and the coccygeal bodies are abundantly supplied with branches of the sympathetic nerve, and are included by Luschka in a group of *appendages to the nervous system*. The suprarenal capsules are developed in intimate association with the sympathetic ganglia, and each retains a medullary substance rich in nerve-cells.

The ductless glands are all very vascular, and, from the circumstance that they bear functional relations to the composition of the blood-corpuscles, both red and white, as well as in some instances (*e. g.* the spleen and the thyroid body) holding secondary positions as blood-diverticula or reservoirs, are named by some observers *appendages to the blood-vessel system*, or *blood-vessel glands*.

With the exception of the intercarotic and the coccygeal body, the ductless glands are abundantly supplied with lymphatics.

Some of the ductless glands, as the spleen, the thyroid body, the thymus body, the suprarenal capsules, the intercarotic body, and the coccygeal body, exhibit a tendency to divide or to form supplemental masses.

The functions of the ductless glands are in a measure supplemented in the fœtus by the liver, and in the adult by the medulla of bone. The lymphatic glands, together with the ductless glands, are most active during infancy and adolescence.

The best arrangement of the ductless glands for practical purposes is that based upon the regions in which they occur.

A Classification of the Ductless Glands.

Head, Neck, and Thorax.	I. Pituitary Body.
	II. Thyroid Body.
	III. Intercarotic Body.
	IV. Thymus Body.
	V. Adenoid Bodies of the Pharynx.
Abdomen.	VI. Spleen.
	VII. Adenoid Bodies of the Intestine.
	VIII. Suprarenal Capsules.
Pelvis.	IX. Coccygeal Body.

[1] Med. Times and Gaz. 1861, i. 332.

[2] Lancet, 1878, i. 778; also Clin. Lectures by Gueneau de Mussy.

[3] Trans. Path. Soc. Lond. 1874, xxv. 30.

The pituitary body will be described in connection with the base of the Cerebrum, the adenoid bodies of the pharynx with the Pharynx, and the adenoid bodies of the intestines with the Intestines.

THE THYROID BODY.

The Thyroid Body is a symmetrical structure situated in the front of the neck, between the thyroid cartilage and the first six tracheal rings. It presents two lateral lobes connected at their lower portions by an isthmus. Each lateral portion is about two inches long and nine lines wide, and is prolonged above into a conical point, but is thick and rounded below. The general figure, the result of the union of the two halves and the isthmus, is thus widely notched at its upper border, but nearly straight at its lower. The body is convex in front, and concave behind. Its general surface is smooth.

The isthmus is six lines in breadth by six lines in depth, and usually lies over the second and third tracheal rings.

The thyroid body is composed of a dense stroma of a dusky red color, through which are interspersed numbers of rounded spaces, each measuring one-eight-hundred-and-fiftieth of an inch in diameter, lined with epithelium, and filled with a clear fluid.[1]

It receives its blood from the superior and inferior thyroid arteries which gain its periphery.

Its nerves are branches of the sympathetic system, and accompany the arteries within the body of the gland.

The *varieties* in the shape of the thyroid are numerous. Thus the extremities may be absent; or the body may be represented by one-half only. The isthmus may be absent, when two separate thyroid bodies will exist. A process (pyramid of Lalouette) occasionally extends upward from one of the isolated bodies to the hyoid bone. According to Cruveilhier, the pyramid may reach to the thyro-hyoid membrane, only or simply to the middle of the thyroid cartilage. In some cases it arises from the median surface of either of the lateral lobes, notably that of the left side. Sometimes a small muscle, the Levator Anguli Thyroideæ, occupies the place of this process. Accessory thyroid bodies are rarely found in the neck, and may be mistaken for the lymphatic glands. They are placed at the sides of and behind the œsophagus. When large, they may excite difficulty in breathing and swallowing, and may even be a cause of death.[1]

Henle describes the following ligaments in connection with the thyroid gland: (1) Slips of fibrous tissue extending to it from the lower border of the cricoid cartilage. (2) Slips connecting the gland with the trachea; these are to be seen opposite the second tracheal ring. (3) A median ligament extending from the anterior surface of the thyroid and cricoid cartilages to the posterior surface of the gland.

For account of bloodvessel supply, see p. 366.

Development.—The thyroid body arises from the hypoblast, first as a diverticulum of the alimentary canal; it afterward exists separately.

Remarks.—The vesicles of the thyroid body become enormously enlarged in bronchocele. In advanced age, the thyroid body may become the seat of calcification. For extirpation of the thyroid body, see p. 378. For compression of internal jugular vein by the thyroid body, see p. 428.

Hyrtl mentions a case in which the gland had been destroyed by suppuration. Suicides have inflicted fatal wounds by opening the vessels which supply it.

THE INTERCAROTIC BODY.

The Intercarotic body lies behind the common carotid artery, where this vessel divides into the external and internal carotid branches. Variable in size and form, it is commonly oval, and measures about two lines in length by one line in width. At times two rounded masses occupy its place, and less commonly four or five. It is of a yellowish-red color, and yields a parenchyma composed of rounded nerve-cells, fat, and connective tissue. Notwithstanding its small size, the intercarotic body is supplied by several distinct, relatively large vessels arising from the common carotid artery, and it is abundantly supplied by branches of the sympathetic nerve.[2]

THE THYMUS BODY.

The Thymus Body or gland is peculiar to the fœtus and the period of childhood and adolescence. It is best developed about the second year. It gradually disappears after this time, and at puberty has dwindled away to a mere trace. It will be here de-

[1] For bibliography of the thyroid body, see A. C. Cole, Studies in Microscopical Science, 1882, i. No. 25, p. 183.

[1] Madelung, Archiv für klinische Chirurg., xxiv. 71.

[2] The intercarotic body was discovered by C. S. Andersch in 1797; for an extended account, with figure and literature, see Luschka, Hals, 423.

scribed as it appears in the infant. The thymus gland is of an elongated pyriform figure, its base being directed downward, and presents a minutely lobulated structure, more or less concealed by an envelope of connective tissue. It lies in the anterior mediastinum, extending thence into the lower part of the neck, and, when well developed, may reach the lower border of the thyroid body. Within the thorax it rests upon the upper portion of the pericardium, the ascending portion of the aorta, the left innominate vein, and the trachea. It is slightly convex anteriorly, but flat or concave posteriorly. It is two inches in length by one-and-a-half inch in width, two to three lines in thickness, and weighs about half an ounce. It is inclined to be symmetrical, although the right side is commonly the larger. The two parts present rounded borders toward each other, but thin borders laterally. A connecting lobe may occasionally be seen between them. Henle describes associated thymic lobules situated near the main mass at the sides, or lodged upon the nutritive artery. The thymus bears a superficial resemblance to a salivary gland. It presents, like it, a loosely lobulated structure, although its color is more of a pinkish tinge, and its structure is much less compact.

The thymus body is composed of a number of small, compressed lobes (primary lobules of Quain) which are arranged around a central stem or space, extending spirally through the length of the gland. The connective-tissue element is abundant about the lobes, holding them together. Each lobule is made up of from seven to eight rounded masses (secondary lobules of Quain), each of which in turn receives a lateral diverticulum from the main hollow stem. These lobules are cellular, and permit the entrance of capillary bloodvessels. According to Henle, the milk-like fluid which exudes from the thymus after section is held within these lobules, which gradually become converted into cyst-like bodies, having thickened walls. Authorities differ as to the relations of the lobules to the central stem. The presence of a central spiral hollow stem with lateral diverticula is, however, commonly conceded.[1]

The arteries of the thymus gland are derived from the internal mammary and the inferior thyroid. The veins empty into the mammary, into the left innominate veins, and at times into the inferior thyroid veins. The vessels for the most part do not lie upon the surface, but are received within the axis of the gland. The nerves are derived from the pneumogastric and sympathetic nerves.

Development.—The thymus body develops from the hypoblast about the region of the visceral arches of the embryo.

Remarks.—The thymus body, while often classified as an appendage of the bloodvessel system, is more closely related to the lymphatic system than is any other of the ductless glands. Gulliver has determined that the corpuscles of the parenchyma of the thymus are identical with those found in the chyle. G. Rainey[1] believes that the thymus is a true lymphatic gland. The lymphatic vessels passing from it are numerous, and either join the lymphatics of the pericardium and the thoracic lymphatic glands, or empty into the jugular veins at the base of the neck. The morbid conditions of the thymus body cannot be studied separately from those of the lymphatic system, and engorgement of the thoracic lymphatic glands is to be expected when the thymus is primarily affected. Disease of the body is, however, rare. Tumors of the thymus exhibit a tendency to invade the thoracic space from before backward, and may even distort the thoracic walls. Out of forty-two cases collected by F. Riegel, thirty-three were examples of cancer and sarcoma, four were fibrous in character, and five were dermoid. The diagnosis of tumor of the thymus necessitates the exclusion of aneurism of the aorta, and of engorgement of the thoracic lymphatic glands.

[1] For bibliography of the thymus body, see A. C. Cole, Studies in Microscopical Science, 1882, i. No. 27, p. 200.

THE SPLEEN.

The Spleen is that ductless gland found in the abdomen in the left hypochondriac region. Its form may be compared to that of a grain of coffee, one side being convex, the other nearly flat, and divided by a longitudinal depression, called the hilum, into two nearly equal surfaces. The hilum is perforated by a number of openings, ranging from ten to fifteen, and is designed for the transit of the splenic vessels and nerves. The spleen is inclosed by an elastic capsule, and is everywhere covered with peritoneum except at the hilum.

The spleen is the most inconstant in form of the abdominal viscera. Its average length may be stated to be five inches, its width three inches, and its thickness one-and-a-half inch. In the same individual it varies in size, which is dependent upon conditions of the systemic circulation. Its weight is about eight

[1] St. Thomas's Hosp. Rep. 1875, 23.

ounces. Its color is externally a dull red, and internally a deep reddish-brown. As seen after death, the organ has a macerated look, its surface being marked by numerous wrinkles.

The spleen presents for examination three surfaces and four borders.

The *dorsal surface* is convex, and lies directly beneath the left half of the arch of the Diaphragm, to which it is united by a fold of peritoneum. The *ventral* or *gastric surface* is concave, and adapted to the posterior aspect of the convexity of the cardiac end of the stomach. The *inferior* or *renal surface*, especially that part posterior to the hilum, is in contact with the upper portion of the left kidney, the suprarenal capsule, and the left crus of the Diaphragm.

The *anterior border* is thin and notched; the notches are often pronounced, and, as a rule, multiple. The *posterior border* is obtuse, smooth, and without notches, save at its upper portion, where a deep fissure may extend from the border to the hilum. The *upper border* of the spleen is in contact with the Diaphragm in the adult, and with the under surface of the left lobe of the liver in the fœtus, and sometimes in the young infant. The *lower border* is held within a fold of peritoneum, derived from the great omental sac, and lies upon the transverse mesocolon. In addition to the above, a small fold of peritoneum unites the organ to the left extremity of the pancreas.

The spleen is accommodated more or less accurately to the hollow of the Diaphragm, between the ninth and the eleventh dorsal vertebræ, and to the curves of the ninth, tenth, and eleventh ribs. Beyond it laterally, lie the slips of the costal origins of the Diaphragm, the pleural cavity with the lower portion of the left lung, and the wall of the thorax.

The position of the spleen is modified by the movements of the stomach. Thus, when the latter organ is contracted, the longest diameter of the spleen is vertical; but, when it is distended, the longest diameter of the spleen is nearly horizontal. In inspiration it is depressed about an inch, and in expiration it is raised the same distance.

Minute Structure.—The elastic covering of the spleen sends down numerous processes, termed the trabeculæ, which penetrate through every portion of the organ, and are continuous with the sheaths of the bloodvessels. The intervals between the intricate interlacings of the splenic bloodvessels and their associated terminal trabeculæ form openings of an indeterminate size, termed the cellules of Malpighi, which are filled by the splenic pulp. Passing within the pulp are minute branches of the splenic arteries, which bear berry-like or bead-like appendages termed the Malpighian corpuscles.

These corpuscles present an average diameter of from three to four millimetres. They are of an opaque gray color, and of a semifluid consistence. Their walls are ordinarily derived from the sheath of the artery to which they are attached. They are more distinct in early life than in the adult. The pulp is soft, and of a dark, cherry-red color, passing to a mahogany brown, and constitutes the bulk of the organ. In the normal state, the pulp breaks when the spleen is firmly grasped, but in many morbid conditions it liquefies, so that the same manipulation will cause it to flow out like water from a sponge. It contains both colored and colorless elements, which, according to Sappey, may be classed as follows: free nuclei, cells with large granular nuclei, bodies resembling white blood-corpuscles, corpuscles from which the pulp derives its color, and blood-corpuscles in a state of decomposition.[1]

The arteries of the spleen are large and numerous compared with the size of the organ. Each artery follows the trabeculæ, as already described. A noteworthy feature, and one indicating the composite character of the organ, is that the capillaries of the several terminal branches of the splenic artery do not anastomose.

Variations.—Supernumerary spleens (spleniculi), in the form of rounded cherry-like masses, have been not infrequently found inclosed in the peritoneum below the main organ, either free from it or attached by delicate peduncles. As many as twenty-three spleniculi have been met with in the same subject. They may in some instances be found in the mesocolon or the great omentum. In the last-named position they may be mistaken for enlarged lymphatic glands. W. H. Bainbridge[2] found a supernumerary spleen within the omentum which was lodged in the pelvis, where it had exerted pressure upon the upper portion of the rectum, and dragged down the great omentum.

It is tenable to assume that the spleen is composed of numbers of united spleniculi. The notches on its borders may be viewed as imperfect attempts at their resolution, and the limitation of the capillary network of each division of the splenic artery as a practical isolation of the different segments of the spleen from one another. In multiple spleens it would appear that each division of the splenic artery had been simply more completely separated from its fellows than is usual.

[1] For bibliography of the spleen see A. C. Cole, Studies in Microscopical Science, 1882, i. No. 35, p. 238.

[2] Lond. Med. Gaz. 1846, 3d ser. iii. 1053.

Remarks.—Clinical points in connection with the spleen relate to the area of dulness as compared to other areas with which it may be confounded, to abscess, to wounds, and to rupture.

The *area of splenic dulness* is confined to a space defined above by the ninth or the tenth rib, and below by the eleventh or the twelfth. A line drawn from the free end of the eleventh rib to the nipple or to the borders of the axilla, would divide this area in its greatest length. The dulness is continuous behind with that of the left kidney.

The spleen is subject to hypertrophy, a condition which, when due to malarial disease, has received the name of "ague-cake." Ague-cake may extend into the pelvis. When found in association with a gravid uterus, it may be violently compressed and give rise to marked local distress and even peritonitis. Not only does the dulness extend as far as the epigastric and right iliac regions, but the notched border may be felt beneath the integument at the umbilicus, and, if the patient be a female, the spleen may be determined *per vaginam* lying in front of the uterus.[1] Sappey refers to a case in which the spleen extended to the groin, where it had the appearance of a hernia.

The spleen, when malplaced or hypertrophied, may be confounded with the left lobe of the liver. The lobulated anterior border serves to distinguish the splenic tumor. The left hepatic lobe is not apt to be enlarged unless the right is also. The enlargement of the left lobe may thus be indirectly determined.—It may be necessary carefully to discriminate between the area of splenic dulness and that of scirrhous thickening of the stomach, of diseased omentum, of feculent accumulation in the cæcum, of diseased kidney, and of ovarian tumor or hydatids.

Abscess of the spleen may open in one of five different directions, viz., into the peritoneal cavity, which is the most frequent; into the left pleural cavity; into the large intestine; externally through the skin; or through the kidney. Bright[2] records an example of rupture into the transverse colon. The lesion occurred in a female of twenty-five years. The spleen was found enlarged and firmly adherent to the transverse colon, and had formed adhesions likewise to the Diaphragm. The abscess had involved one-half of the spleen, and had ulcerated into the transverse colon at the place of adhesion.

[1] Spencer Wells, Med. Times and Gaz. 1866, i. 2.

[2] Guy's Hosp. Rep. 1838, iii. 425.

Wounds of the spleen are not liable to occur except from without, when, as a rule, both the Diaphragm and the lower part of the left pleural cavity are perforated. In *rupture of the spleen* the parenchyma may suffer without laceration of the elastic coat; in fatal cases, an appreciable interval—in a case reported by Mr. Partridge,[1] five days—has elapsed between the time of the initial lesion and the rupture of the elastic capsule. Spontaneous rupture can occur only in advanced hypertrophy accompanied with softening of the parenchyma. Dr. J. B. Potter[2] records a case in which half a gallon of blood and pultaceous pulp escaped into the cavity of the peritoneum.

THE SUPRARENAL CAPSULE.

The Suprarenal Capsule (adrenal) is a flattened triangular body situated, as the name implies, above the kidney, and held to it by connective tissue at the inner and anterior portion of the superior border. It is not, however, supported by the kidney, but is held in position by its own bloodvessels and nerves; thus in displacement of the kidney the suprarenal capsule remains undisturbed.

Its lower border is broad and concave for the reception of the convex border of the kidney. Its upper portion is narrow and convex or straight. Both anterior and posterior surfaces are broad and nearly flat, the latter being slightly convex, and ordinarily exhibiting a groove for one of the capsular veins.

Both organs rest upon the crura of the Diaphragm. The anterior surface of the left suprarenal capsule lies behind the spleen and fundus of the stomach, and occasionally retains also a relation with the tail of the pancreas. The anterior surface of the right capsule is in contact with the liver, and lies behind the first portion of the duodenum. The superior border of the capsule of the right side is near the inferior cava, while that of the left is near the semilunar ganglion. The anterior surface is distinguished by a groove named the hilum, extending from within outward, and presenting rounded borders. It transmits the capsular vein.

The capsule measures one-and-a-fourth to one-and-three-fourths of an inch in length, one-and-a-quarter inch in width, and from two to three lines in thickness. Its weight is from one to two drachms. These measurements and weights are subject to slight varia-

[1] Med. Times and Gaz. 1866, i. 350.

[2] Western Lancet, 1845, iii. 412; see, also, Dr. J. Neill, Amer. Journ. Med. Sci. 1842, n. s. iv. 369. Literature.

tion in different individuals and upon opposite sides of the body.

Minute Structure.—The organ is surrounded by a thin fibrous capsule from the inner surface of which delicate trabeculæ extend into the parenchyma. This is divided into two portions, an outer or cortical, and an inner or medullary.

The outer or cortical portion presents on section a yellowish-brown color, and is of firm consistence. Upon microscopic section it is seen to be composed of fasciculated groups of cells arranged in a columnar manner from without inward. At either end of this arrangement of cells are groups of others smaller and rounded. The cells contain yellowish pigment-matter and oil-globules.

The inner or medullary portion is of a blackish or liver-brown color, and of soft consistence. When examined in a perfectly fresh condition, it is seen to be solid, but it soon undergoes decomposition in the centre, as a result of which a cavity forms which has been described by some writers as normally existing. The medullary portion differs from the cortical in the fact that it presents rounded cells only, and in the fact that these cells contain blackish pigment-matter, though no oil-globules. These cells are loosely imbedded in a delicate connective-tissue stroma.

The suprarenal capsule is very vascular. The arteries are derived from branches of the inferior phrenic and renal arteries, and often, in addition, directly from the aorta.

The veins are numerous and disproportionately large. They are collected in a single trunk which escapes from the *hilum*. The right vein joins the inferior vena cava, the left the corresponding renal vein. A capillary network is established in the cortical portion.

The nerves, which are present in greater number than in any other of the ductless glands, are derived from the solar and renal plexuses of the sympathetic system, though distinct accessions have been seen passing from the pneumogastric nerve. These, together with the vessels, serve to keep the organ in position. The connective tissue of the medulla is believed by some writers to be in continuity with the nerves, and it is claimed that nerve-cells are seen intermingled with the cells of the medulla.

The capsule is, in relation to the kidney, larger in the fœtus.

Variations in form are frequent. Rarely the capsule is rounded or elliptical instead of triangular. It has been known, when enlarged by disease, to compress the thoracic duct. Accessory bodies of a small size and rounded form are occasionally seen.

The suprarenal capsule probably has more essential relations with the nervous than with the bloodvessel system. In Addison's disease, morbid changes are in some cases recognized in these bodies. These changes, however, are by no means constant.

THE COCCYGEAL BODY.

The Coccygeal Body is a gland-like structure appended to branches of the median sacral and lateral sacral arteries, and lodged in an interspace between the fibres of the Levator Ani and the Sphincter Ani muscles, directly in front of the tip of the coccyx. It is of the size of a split pea, of a grayish-red color, and firmly held down by connective tissue, which, besides enveloping it, penetrates the body in all directions to form a network of coarse fibres. The parenchyma is lodged in these meshes of connective tissue, and is composed of epithelial cells arranged in little clumps, in the centre of each of which lies a minute arteriole. The vessels of the body are relatively large and numerous, and effect many anastomoses. The nerves are also remarkable for their number and size, and are derived from the sympathetic. The coccygeal body is thus seen to be closely allied with the intercarotic body. Luschka, who discovered it, calls it a "nerve-gland," and believes that this gland forms with the intercarotic body and the suprarenal capsule, a natural group of structures.

Remarks.—J. Y. Simpson[1] detected morbid conditions in and about the coccygeal body which he included under the clinical term coccygodynia. The condition is supposed to represent the results of injuries received at the region of the coccygeal body and of the nerve and osseous structures in its neighborhood (see p. 119). R. Heschl[2] found the coccygeal body to be the seat of a variety of cystic degeneration in congenital malformation of the pelvis and its contents.

[1] Clinical Lectures, 202.

[2] Œst. Zeit. für prakt. Heilkunde, 1860.

ALLEN'S

HUMAN ANATOMY.

NERVOUS SYSTEM.

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THE NERVOUS SYSTEM.

GENERAL CONSIDERATIONS.

The Nervous System includes those portions of the economy which are engaged in the elaboration, reception, and conduction of nerve-force. Two subsystems of the nervous systems are recognized, viz.: the cerebro-spinal system, and the sympathetic system.

The *cerebro-spinal system* embraces the brain, the spinal cord, and the nerves which pass from and the nerves which are received within these structures. The brain and the spinal cord constitute the *cerebro-spinal axis*, or the *central nervous system*.

The *sympathetic system* embraces the ganglia and nerves which do not belong to the cerebro-spinal system, and which are found outside of the vertebral canal and the brain case in the head, the neck, and the cavities of the trunk.

The following terms are employed in describing the nervous system:—

Nerve-Cell.—A cell that generates nerve-force.

Ganglion.—A collection of nerve-cells.

Neuroglia (nerve-cement, nerve connective-tissues).—A form of connective-tissue in which are imbedded nerve-cells and nerve-fibres.

Gray Matter (spongy matter, cineritious matter, ganglionic matter).—A term of convenience employed to denote those portions of the nervous system which are composed of nerve-cells.

Gray Commissure.—A narrow band of gray matter which unites large tracts or masses.

The Gray Matter is distributed as follows:—

It is arranged in the spinal cord in the form of two longitudinal columns, connected by the anterior and the posterior gray commissure. It extends into the brain, where it is called the *central gray matter*. Or it is arranged on the periphery of the cerebrum and the cerebellum, where it is called the *cortical gray matter*. Or it is collected in isolated bands or nuclei, such as the *dentate body*, *olivary body*, etc.

The terms "ganglia" and "gray matter" are often used interchangeably. The gray matter of the spinal cord is assumed, from analogous structures in some invertebrate animals, to be made up of a number of coalesced ganglia. In a physiological sense, the term ganglion is synonymous with nerve-centre. Thus, Flourens describes the respiratory centre at the floor of the fourth ventricle as the vital ganglion. Isolated ganglia, apart from those belonging to the sympathetic system, are met with on the posterior root of spinal nerves, and on the pneumogastric, the glosso-pharyngeal, and the trifacial nerves.

Nerve Fibre.—A fibre whose function it is to conduct nerve-force. A Nerve-fibre is *medullated* when it is surrounded by medullary sheath or substance, and is *non-medullated* when it is not (see p. 76).

White or Medullary Matter.[1]—Masses of nerve-fibres in the central nervous system.

Nerve-Tract (nerve-column).—A pathway or commissure composed of nerve-fibres for the conduction of nerve-currents. A nerve-tract is best defined in the developing nervous system. It is ordinarily determined by clinical and physiological methods.

Nerve-tracts are *centrifugal* when they pass from the brain to the spinal cord and the body; they are *centripetal* when they pass from the body to the spinal cord and the brain. In these definitions the brain is of course the "centre," and the spinal cord the "periphery." Nerve-tracts are *afferent* (periphero-central) when they are received into the spinal cord or into

[1] The different uses of the word "medulla" need not cause confusion if it is remembered that in all instances it represents the *pith-like contents* of a rod or cylinder, whether such rod or cylinder be rudely represented by the brain-case together with the vertebral column, by the sheath of a nerve, or by the shaft of a bone.

a sympathetic ganglion; they are *efferent* (centro-peripheral) when they pass from the spinal cord or from a sympathetic ganglion. They are *sensory* when they are known by physiological or clinical methods to control sensation; and *motor* when, by similar methods, they are known to control motion. Motor nerves of bloodvessels are of three kinds—*accelerator*, *depressing*, and *inhibitory*. Sensory nerves are of three kinds—those of *general sensibility;* those of *tactile sensibility;* and those of *special sensibility*, as the optic, auditory, and olfactory nerves. To these may be added the *trophic* nerves which are assumed to control nutritive processes.

Nerve-Sheath (perineurium).—A sheath of connective-tissue inclosing a nerve.

White Commissure.—An internunciary bundle of nerve-fibres uniting groups of nerve-cells in the spinal cord or the brain.

Fissure (sulcus, groove).—A narrow space between superficial inequalities of the spinal cord or of the brain.

Convolution (gyrus).—A portion of the superficial gray matter of the cerebrum or of the cerebellum which is embraced between two fissures.

Neurology treats of all the properties of ganglia, of the nerves in connection with the ganglia, and of the general properties of nerve-tissues.

The nerves are flattened cords of a dull-white color, composed of coarsely fasciculated nerve-fibres. Each nerve of the cerebro-spinal system is said to arise from some portion of the brain or the spinal cord. The connection of the fibres with nerve-cells is said to constitute the *real* or *deep* origin of the nerve; while the point at which the fibres become apparent at the surface of the brain or the spinal cord is said to be its *apparent* origin. Thus the apparent origin of the olfactory nerve from the neighborhood of the anterior perforated space at the base of the cerebrum is a consideration of less importance than is the real origin of the fibres of the nerve from the cortex of the occipital and spheno-temporal lobes. In an exact sense, sensory nerves may be said to arise from sentient surfaces, and to end in the central nervous system. Many of the bundles of nerve-fibres composing the medullary matter of the cerebro-spinal axis are in direct continuity with the nerves. In clinical relations such deep origins are of chief importance.

Nerve-trunks possess a tendency to form *commissures* which unite distant groups of nerve-cells; to interlace among themselves to form *nerve-plexuses;* and, being longitudinal, to be deflected obliquely across the median line of the body to form *decussations*.

Commissures are of two kinds, the longitudinal and the transverse. Great numbers of *longitudinal fibres* in the spinal cord pass from lower to higher groups of nerve-cells. In the brain some analogous fibres are isolated in part from the surrounding medullary matter, and have received distinctive names. Such are the fornix and the longitudinal fibres of the corpus callosum. The *transverse commissures* unite nerve-cells that lie to the right and left of the median line. The nerve-fibres, in front of the central canal of the spinal cord, the corpus callosum, and the anterior commissure will serve as examples. Among the nerve-trunks many of the sympathetic nerves are seen to be commissural bands uniting the different ganglia. In the articulate type of animals, as in the insect and the crustacean types, the ganglia of the cerebro-spinal axis are united by naked commissures.

Plexuses result from the union of loose networks of commissural fibres of the type connecting the sympathetic ganglia, and of those seen in the branches of the spinal nerves. They are particularly noticeable in the sympathetic system and among the spinal nerves which supply the head, neck, and limbs just after they escape from the vertebral canal.

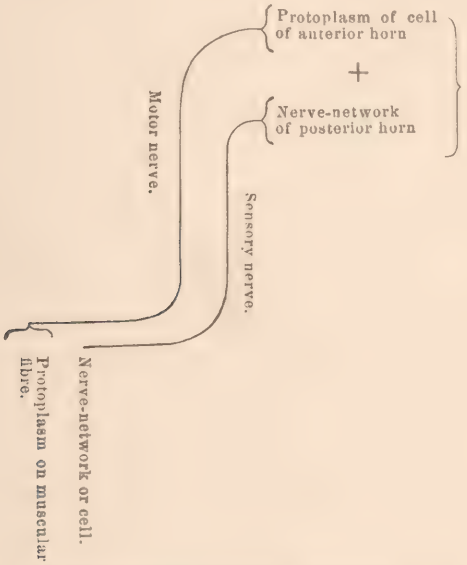
Decussations are central and peripheral. *Central decussations* are those which occur in the cerebro-spinal axis. The decussating fibres may be deep, and not isolated from the surrounding medullary substance, as in the decussations at the pons Varolii; or they may be superficial, as at the anterior pyramid of the medulla oblongata. *Peripheral decussations* are confined to the crossing of fibres of a pair of cerebro-spinal nerves. The best example is seen in the decussation (chiasm) of the optic nerves. In lizards and some turtles the right and the left hypoglossal nerves decussate over the region of the hyoid bone.

The separate nerve-fibres terminate in three ways: in protoplasm; in networks of loops; or in special cells, which are as a rule of epithelial origin.

A *nerve-network* is a reticulate union of axis-cylinders, and is used in a sense distinct from that of a *nerve-plexus*. It is a histological term.

The nerves ending in protoplasm form the *motor nerves*. They arise centrally from the protoplasm of the nerve-cells, carry, in part, protoplasmic processes of these cells, and terminate peripherally in pads of protoplasm on muscle-fibre. The nerves ending in networks and loops or cells are the *sensory nerves*. Anatomists are not agreed either as to the origin

or the termination of these fibres. It is commonly assumed that they arise from the interlacements of the fibrillar cell-network of the spinal cord, and end in loose networks or loops on the periphery. Special sentient surfaces are often appended to the sensory nerve-endings, which exhibit great variety. Such are the tactile corpuscles, the Pacinian corpuscles, and the retina.



A Diagram Contrasting the Beginnings and Endings of a Motor and a Sensory Nerve.

Variations of Nerves.—The manner in which nerve-trunks divide to supply muscles which are related in function is of importance in determining homologies, and in ascertaining the significance of variations in the human subject. It is evident, that observers, in recording anomalies of nerve-trunks, should in every instance include in their description the anomalies of the muscles on which the nerves end, and that they should search for any correlative variations in that portion of the central nervous system from which the nerves arise.

The foramina of the skull through which nerve-trunks pass are subject to fewer variations than are those for the passage of bloodvessels. Anatomists attach great weight to the arrangement of such foramina; and in all instances of unusual disposition of parts, particularly at the base of the skull and in the component parts of bones which have complex origins, they should be carefully examined (see p. 104).

Nerves will exhibit variations in the degree in which trunks of different peripheral distributions are bound in the same sheath.[1] When two nerve-trunks are thus mechanically associated, they may be said to be *fused*. The degree of fusion in the spinal nerves which supply the superior extremity varies in different mammals, being, for example, less marked in the raccoon and the opossum than in the cat, and in some human subjects than in others.

Nerves will be found to vary, according as they supply superficial or deep parts. Those to the deeper muscles of a limb tend to be shorter than those passing to the more superficial muscles.

The Distribution of Nerves.—The larger nerves are found in company with the important vessels, if, indeed, they do not determine the positions of the blood-vessels, and are either protected by muscular masses, or, if exposed, as at the region of the joints, are apt to be protected by the lines of flexion of the limbs. According to Hilton,[1] the muscles receive the nerves upon the under surfaces. Exceptions to this rule are noted in the External Oblique of the abdomen, and in the Abductor Pollicis. The termination of nerves in muscles is found by G. Schwalbe[2] to be influenced by the shapes of the muscles. The Teres Major, Teres Minor, Tensor Vaginæ Femoris, and the periocular muscles, muscles whose planes of origin and insertion are of equal width, and whose fibres are parallel to one another, receive the nerves —one for each muscle—in the middle. Muscles such as the Sartorius receive several nerves, all of which occupy a line of determinate value, called the nerve-line, whose ends are equidistant from the distal and proximal ends of the muscle. Muscles of a triangular form—such as the Subscapularis, Pectoralis Major, Pectoralis Minor, and the Adductors of the femur—whose fibres tend to converge toward the narrowed end, receive the nerve near the point of convergence.

Hilton[3] ascertained that a nerve supplying a deep sentient part, as the interior of a joint, will also send a branch to the skin lying over the joint. The same sensory nerve supplies the interior of the eyeball, the periocular space, and the eyelids.

Nerves which supply muscles of a given group, and are thus dominated by centres in the cerebro-spinal axis whose limits are known, are said to be *synergic*.

The Degeneration of Nerves.—It has been seen that the motor and sensory nerves are distinguished by their methods of origin and distribution. But their isolation in a bundle of nerve-trunks cannot in this way be determined; while nothing definite is known

[1] See, in connection with this subject, Moritz, Zeitschr. für Anat. und Entwickelungsgeschichte, 1876, 82.

[1] Lectures on Rest and Pain, 170.

[2] Archiv für Anat. und Entwickelungsgesch. 1879, 167.

[3] Loc. cit., 157.

of the structure or termination of trophic nerves. In some examples, such as the hypoglossal nerve, the association with the branches of the cervical plexus can be ascertained by careful dissection, and in other instances by stimulation by an electrical current of the trunk in the living animal. When these means cannot be resorted to, a method, originally suggested by Waller,[1] and known after his name, may be employed to isolate the motor and sensory nerves, and to aid generally in determining the character of any given association of nerves. According to this method, a nerve, when separated, as by a transverse section, from the nerve-cells dominating it, will pass into a condition of degeneration. For example, the cells of the anterior horn of the gray matter of the spinal cord dominate the motor nerves arising from them. Separation of these nerves from the cells will cause the motor tracts in a mixed spinal nerve to degenerate, while the sensory tracts will remain unchanged.—The ganglion on the sensory root of a mixed spinal nerve dominates the nerve-tract which passes thence to the spinal cord. Separation of these tracts from the ganglion will cause degeneration in all the fibres which enter the posterior-lateral fissure of the cord. By pursuing a similar method, the mixed character of the spinal accessory and the pneumogastric nerve has been ascertained with great accuracy, and the spinal origin of many of the nerves which enter into the sympathetic system has been in part determined.

It is evident from the foregoing statement that the division of the nervous system into central and peripheral portions is arbitrary, and that it is of convenience in the study of topographical anatomy only. In the consideration of all indirect or clinical relations, such a division may be discarded. Motor nerves are best conceived as bands extending between pads of protoplasm: one pad, the central, lying in the gray matter of the spinal cord; the other pad, the peripheral, lying in the muscle-substance. No given portion of this nerve-tract, though it involves the intrinsic fibres of the spinal cord, the spinal nerve, and the plexus, or nerve-trunk of the limb, can be separated in any other way than conventionally from any other portion. Insufficient knowledge alone prevents a similar formulation of the beginnings and endings of sensory nerve-trunks; although it is probable, from the researches of Erb and Sachs, that networks of minute axis-cylinders in part take the place of the protoplasm of the motor cells. With regard to nerves of special sensibility it has been shown that evulsion of the eyeball causes degeneration of those portions of the optic lobes and of the optic tracts which are connected with the optic nerve of the side operated upon.

The influence exerted upon the motor cells of the spinal gray matter by the integrity of the limb is evident from the effects upon this gray matter of amputation of the limb. The cells become fewer in number and atrophied at the point from which arose the nerves which supplied the limb.[1] (See Remarks.)

The effect of disease of the motor cells upon motor nerves is in harmony with this statement. The muscles supplied by such nerves become atrophied and subject to fatty degeneration. It is of great interest to remark that, while all the muscles of a limb are not equally affected by disease of that portion of the spinal cord which controls the limb, the several muscles respond unequally to the central influences. Thus, in a case of infantile spinal paralysis, reported by Charcot and Jeffroy,[2] followed by death at the fortieth year, while both Psoas muscles were atrophied, the left Pectoralis Major alone was involved; while the right were normal, the left Deltoid and the left Triceps were atrophic; while the superficial were normal, the right deep flexors of the fingers were atrophic, etc. In a case reported by Otto Barth,[3] in a male who died at forty-four years of age, the lesions were confined to the supinators of the left forearm, to the Quadratus Femoris, and to the Gastrocnemius of both sides. In a somewhat similar case recorded by A. Vulpian,[4] all the muscles of the right leg, excepting the Extensor Communis Digitorum, were fatty; the right Rectus Femoris and the Vastus Internus were fatty, while the right Vastus Externus was not. It is evident that the causes of protection of some muscles of a natural group which is tending to degeneration and atrophy cannot be explained by the influence of central diseased action alone. It is probable that, under the conditions of impaired vitality to which all the muscles of a given set are subjected, some muscles will be protected by degree of use, by peculiarities of bloodvessel supply, or by other local causes which are withheld from the remaining muscles of the group.

[1] Philos. Trans. 1850, 425; also Proc. Roy. Soc. 1856–7, 69. For general bibliography of the subject of degeneration of nerves after their section, see M. L. Ranvier, Leçons sur l'Histologie du Système Nerveux, Paris, 1878, 352.

[1] A. Vulpian, Arch. de Physiologie, i. 445, ii. 680; L. Edinger, ibid. 1882, lxxix. 46; ibid. 1882, 1883; W. H. Dickinson, Journ. of Anat. and Phys. 1868, iii. 88; Dreschfeld, ibid. 1879, xiv. 424. Literature, figs.

[2] Archiv. de Physiol. 1870, iii. 134.

[3] Archiv der Heilkunde, Heft 2, 121.

[4] Archiv. de Physiol. 1870, iii. 316.

In an interesting example of the tracts of degeneration, which in a measure answer to the groupings of muscles about separate nerves, W. Müller[1] found, in a subject in which was detected atrophy of the left anterior cornu of the gray matter in the cervical and lumbar enlargements and parts of the dorsal portion, that the muscles supplied by the right anterior crural nerve, the right peroneal nerve, and the right posterior interosseous nerve of the forearm were atrophied. But, in the same subject, irregularly isolated atrophies occurred in the right Quadratus Lumborum, the right first and second intercostal muscles, the left Deltoid, Triceps, hamstrings, and extensors of the foot, while in the Psoas muscles the degeneration was bilateral.

It has been seen that the extensory and abductory muscles are related, and are weaker than the flexors and adductors (see p. 245); and it is interesting to note that clinical writers on nervous diseases find that the nerves controlling these muscles are thus morphologically associated; that they are also of less vital resistance, and are sooner exhausted than are the centres for the flexors and adductors—the vocal cord abductors being notably less able to resist paralysis than the adductor; and that a systemic depressing cause will, as in lead-poisoning, show itself first in the extensors.

A Classification of the Parts of the Nervous System.

I. The Cerebro-Spinal Axis.
  I. The Spinal Cord.
  II. The Brain.
  III. The Peripheral Nerves.
    I. The Spinal Nerves.
    II. The Cranial Nerves.
II. The Sympathetic System.

THE SPINAL CORD.

The Spinal Cord (medulla spinalis) is that portion of the cerebro-spinal axis lying in the vertebral canal. It is of a cylindrical form, slightly compressed from before backward, and, on the whole, diminishes in size from above downward. In the fœtus and in the new-born child, the spinal cord extends, without material diminution in diameter, the entire length of the canal. But, as the vertebral column increases in length, the cord terminates at a higher point, and in the adult its lower end answers to the plane of the lower border of the body of the first or the second lumbar vertebra. According to C. Fehst,[1] the spinal cord in the female is apt to reach the level of the second lumbar vertebra. The space between the lower end of the cord and the end of the canal which accommodates it is occupied in part by a slender filament of gray matter called the *terminal filament.*

The spinal cord measures eighteen inches in length, and weighs about one-and-a-half ounce. Its circumference is about twelve lines, but at the largest part it may be thirteen lines.

The spinal cord, for convenience in description, is divided by the position of the origin of the spinal nerves into three portions: the cervical, the dorsal, and the lumbar. The *cervical portion* is broader from side to side than from before backward. The *dorsal portion* is nearly circular. The *lumbar portion* is somewhat thicker from before backward than from side to side.

The spinal cord exhibits two enlargements, which are known as the cervical and the lumbar enlargements. The *cervical enlargement* (intumescentia cervicalis) extends from the third or fourth cervical to the second dorsal vertebra, and the *lumbar enlargement* (intumescentia lumbalis) from the tenth dorsal to the first lumbar vertebra. The tapering end of the lumbar enlargement is known as the *conus medullaris.* It may be said to lie behind the inferior border of the first lumbar vertebra.

The cord is divided into lateral halves by two longitudinal grooves occupied by connective tissue and bloodvessels, and named from their positions the anterior and posterior median fissures. The *anterior median fissure* (anterior longitudinal fissure) is the broader and the shallower of the two, equals in depth one-third of the diameter of the cord, is lined by a fold of pia mater, and lodges bloodvessels of a larger calibre than those in the posterior fissure. The *posterior median fissure* (posterior longitudinal fissure, septulis)—having a diameter equal to one-half the diameter of the cord—is deeper, but much narrower than the anterior. The posterior fissure is entirely occupied by a network of pia matral fibres; for this reason it has been described by some writers as a septum.

Each lateral half is semi-cylindrical in form. The smooth and flat median surface is interrupted by a commissure, and the undulating convex lateral surface

[1] Beiträge zur Pathолog. Anatomie und Physiologie des Menschlichen Rückenmarks, Leipzig, 1871, Case 2.

[1] Centralblatt f. d. medicin. Wissenschaft., 1874, xii. 741.

is marked by a prominent depression—the *postero-lateral fissure*—which, in some portions of the cord, is as conspicuous as the antero-median fissure. It is designed to receive the round bundles of the posterior nerve-roots.

The posterior lateral fissure divides the lateral half of the cord into two columns: the *antero-lateral column*, which lies between the antero-median fissure and the postero-lateral fissure; and the *posterior column*, which lies between the postero-lateral fissure and the postero-median fissure.

Subdivision of the antero-lateral columns.—The antero-lateral column is conventionally divided into two portions, viz.: first, the *anterior column*, lying between the anterior median fissure and an imaginary line along a slightly depressed surface—the *antero-lateral fissure*—and uniting the points of exit of the first bundles of the anterior nerve-roots; and, secondly, the *lateral column*, lying between the same imaginary line and the postero-lateral fissure. The anterior column is slightly raised above the level of the lateral column.[1]

Subdivision of the posterior columns.—The cervical portion of the spinal cord is divided into two columns by the position of a fissure, which, from its position, is called the *postero-intermediary fissure*. It extends from the medulla oblongata to the lower border of the cervical enlargement, and it is the only fissure in the cord that is not created by the transit of nerve-roots. That portion of the cord lying between the postero-median fissure and the postero-intermediary fissure is called the *postero-median column*.[2] That portion lying between the postero-intermediary fissure and the postero-lateral fissure is called the *postero-lateral column*.[3]

Recalling the fact that the columns of the spinal cord are continuous with those of the medulla oblongata, and that the separation of the cord from the medulla is purely arbitrary, the columns of the cord can be traced upward to the medulla as follows: The anterior column is continuous with the anterior pyramid, the lateral column with the restiform body, the postero-lateral column with the funiculus cuneatus, and the postero-median column with the processus gracilis.[1]

When a transverse section (*i. e.*, one perpendicular to the longitudinal axis) of the spinal cord is made, the surface is found to be marked off into dark and white portions. The *dark portion* takes the form of a crescentic bar or nucleus in the centre of the *white portion* of each lateral half of the cord, and together with a band or commissure of similar substance uniting them, constitutes the gray or cineritious matter. Each bar is rounded and wide in front, where it forms the *anterior horn* or *cornu;* it is enclosed by white matter. The posterior end of the bar is pointed to form the *posterior horn* or *cornu*, and is, in part, continuous with the postero-lateral fissure. The tip of the posterior horn is called the *caput*, and the slightly narrowed part near its base the *cervix*. The white matter (medullary matter), as already stated, surrounds the gray matter except at the tips of the posterior horns and at the posterior surface of the commissure. At the *conus medullaris* it is inclosed by white matter.

Consistence.—When examined in a fresh state the spinal cord is of firmer consistence than the brain, and when cut transversely presents a clean surface, of which the contours are sharply defined. When examined six or eight hours after death at a temperature of 68° or 70°, the cord is soft, the plane of its transverse section is convex, and the contours are swollen and irregular. The white matter in certain diseased conditions may be abnormally soft, and may project from the plane of the transverse section while the gray matter appears depressed.

The minute anatomy of the spinal cord.—The minute anatomy of the spinal cord includes an account of the following constituents:—

Connective Tissue Matrix.
Central Canal.
Nerve-cells.
Nerve-fibres.
Bloodvessels.
Lymph-spaces.

The Connective Tissue Matrix (neuroglia, nerve-cement, gelatinous substance) gives form to the spinal cord, and furnishes the framework for the accommodation of the nerve-cells and nerve-fibres.

[1] This elevation is more marked in the cervical portion of the cord than elsewhere. It is conspicuous in some of the lower animals, especially the frog.

[2] Column of Goll, funiculus cuneatus, cuneiform column (Kölliker), internal slender tract of posterior column, posterior internal column (Grassett), dark posterior column (Goll), external fascicle (Burdach), marginal funiculus (Gratiolet).

[3] Column of Burdach, posterior root-zone (Charcot), funiculus cuneatus (Flechsig), postero-external column (Gowers).

[1] According to E. Spitka (Chicago Med. Review, 1881), the posterior columns are in part continuous with the restiform body and the cerebellar tract, and reach the cortex of the cerebellum; the postero-lateral are traceable to the vermis of the cerebellum.

The connective tissue is of a more delicate character than that seen in other parts of the economy, and is best defined in those portions of the cord not occupied by the nerve-cells or fibres. These sterile places are most conspicuous in the periphery; at the borders of the fissures; round the central canal; and to the median side of the caput of the posterior horn.

The connective tissue, as it lies about the central canal, forms the *substantia reticularis* (substantia gelatinosa reticularis), and is well developed in the fœtus at the sixth month; that about the caput of the posterior horn forms the *substantia gelatinosa* (substantia gelatinosa posterioris). This patch is of an oval figure in the cervical and in the dorsal portion of the cord, but is circular in the lumbar portion. It is continuous above with the tubercle of Rolando. In the cord it lies along the median border of the posterior horn, near the *caput cornu*, and is in a measure invested by it. Thus, there is more connective tissue in the gray matter of the posterior horn than in the anterior, a fact which assists the observer in explaining the frequent occurrence of inflammatory affections in the posterior portions of the cord. In color the substantia gelatinosa is darker than the connective tissue elsewhere, and for this reason it was formerly included in the gray matter of the cord. The cells of the matrix of the connective tissue can with difficulty be distinguished from the smallest of the nerve-cells.

Between the cell-layer and the *substantia reticularis* is seen a special form of connective tissue known as the *ependyma*, which is continuous with the tissue of the same name lining the ventricles of the brain.

Apart from the sterile areas above named, the connective tissue is not evenly distributed throughout the cord. A great number of slender bands of connective tissue (septulæ) penetrate the cord from the periphery, and serve to divide the white matter into compartments. On the whole it may be said that a larger amount of connective tissue is seen in the posterior horn than in the anterior horn; in the postero-median and postero-lateral columns than in the antero-lateral column; and in the superficial parts of the medullary matter of the entire cord than in the deep parts.

The Central Canal is a minute passage in the interior of the spinal cord. It is continuous above with the fourth ventricle, and is lined with columnar epithelium. The canal is well developed in the spinal cord of fœtal life, at which period the epithelial cells bear cilia, but in the adult the cells are without cilia, and the canal, through the greater part of its length, is obliterated by cell-debris. The canal in size and shape varies in different parts of the cord, being transversely oval in the cervical portion, circular in the dorsal, and cordiform or T-shaped in the *terminal filament*. Its size is proportionate to that part of the cord in which it lies. It is thus wider in the cervical and lumbar enlargements than elsewhere.

The Nerve-Cells compose the gray matter of the spinal cord. The gray matter (spongy substance, vesicular substance) is composed of a right and a left half, and of a commissural tract, which is made up of an anterior and a posterior gray commissure.

If considered as a single mass, the gray matter forms a channelled column of irregular outline, extending through the cord, widening, and becoming less compact as it merges into the gray matter of the medulla oblongata, but becoming less fluted as it ends below in the *terminal filament* without covering of nerve-fibres. It may be said, in a general way, that the column is deeply fluted in front and behind by single incurvations extending nearly to the centre of the cord, and at the sides by two shallow excavations of varying depth. The anterior and the posterior excavations reduce the central portion of the cord to a thin lamina, and tend to convert the lateral parts into two irregularly crescentic bars. The gray matter in front of the substantia reticularis is the *anterior gray commissure*, and that behind the same tissue is the *posterior gray commissure*. The gray commissures are twice as thick as the white except in the cervical portion of the cord, where the white matter exceeds the gray in diameter.

The median contours of the anterior and the posterior horns are smooth and uninterrupted. The lateral contours are, on the other hand, frayed, and they present two special modifications of the form of the crescent, which are named as follows:—

The Intermediary Lateral Tract.

The Reticular Process.

The Intermediary Lateral Tract (tractus intermedio lateralis, middle horn) is placed nearly midway between the anterior and posterior gray columns, in the posterior part of the cord. It is of a wedge-shaped figure[1] when seen in transverse section, the base being upward.

[1] From this fact the intermediary lateral tract is sometimes called by clinical writers the pyramidal tract. Such a use of the term is unfortunate, since the pyramidal tract, as restricted by most observers, is of great practical importance, and is composed of nerve-fibres traceable both up and down the cerebro-spinal axis, from the anterior pyramids of the medulla oblongata. See Minute Structure of the Cerebrum.

The Reticular Process (processus reticularis, process of Lenhossek) is placed at the base of the posterior horn. It is composed of an irregular figure interrupted by a network of fibres and connective-tissue matrix.

Careful examination shows the nerve-cells to be distributed into six separate sets or clumps, viz.: The anterior, the median, and the lateral clumps of the anterior horn; the cells of the vesicular column; the cells of the intermediary lateral tract; and the cells of the posterior column.

The cells of the anterior horn are the most conspicuous of any in the cord, those of the lateral set being the largest. These cells are remarkable in possessing the *protoplasmic processes of Deiters* (see p. 85), which extend outward in company with the nerve-roots of motor nerves. The cells of the vesicular column lie to the median side of the posterior horn near the base. In the intermediary lateral tract, the cells are without the processes named, but are connected with the peripheral cerebellar tract of Flechsig.—The cells of the posterior horn are the smallest in the cord, and are without protoplasmic processes.

Dr. Jas. Ross[1] proposes to name as a median group —restricting the term median as above limited to the *internal*—a collection of cells in the cervical and lumbar enlargements at the median-basal aspect of the anterior horn. This group contains caudate cells, and is of relatively large size. From the fact that the cells assume processes after birth only—the remaining group having processes as early as the fifth month—and the cells being best developed in the cervical enlargement, Ross infers that in the median area are mainly organized the complicated movements that distinguish the hand of man from the anterior extremity of the lower animals so far as these movements are represented in the spinal cord.

The Nerve-fibres compose the white matter (medullary substance) of the spinal cord. They are disposed in groups of longitudinal, oblique, and horizontal fibres.

The *longitudinal fibres* compose the bulk of the column, as already defined. They are arranged in bundles, the interstices and the boundaries of which are made up of connective-tissue. In this manner the columns of the cord, as defined among the naked-eye appearances, can be easily identified when transverse sections are prepared for microscopic observation.—

[1] Brain, 1880, iii. 81, fig.

The *oblique fibres* are interspersed among the longitudinal fibres; but they are relatively few in number. Many of them represent the fibres of termination of the posterior nerve-roots.—The *horizontal fibres* are seen in the anterior commissure and in some of the fibres of origin of the anterior nerve-roots.

The postero-median column.—Carefully studied, this column is seen to be defined medianly by the posterior median fissure, laterally by the posterior lateral column. In the cervical region it is defined centrally by the *substantia reticularis*, but as the column descends the cord, it gradually recedes from the middle of the median fissure. The periphery is broad and compressed, but is narrow and elliptical in the lumbar region.[1]

The *postero-lateral column* is defined laterally by the postero-lateral fissure, and medianly by the postero-median column. Centrally it is traversed by fibres of the posterior nerve-roots. In consistence the columns of the posterior parts of the cord are less compact than are the anterior columns, and possess finer fibres.

The origin and termination of the spinal nerves in the spinal cord.—The anterior nerve-roots pass out in obliquely directed bands, and form with the axis of the cord a number of acute angles, those of the fifth sacral nerve and the coccygeal nerve alone excepted, which pass out at right angles. The nerves take their origin either as protoplasmic processes from the cells of the anterior horn, or as axis-cylinders grouped in pencil-like bundles about the cells. The last named, according to Gerlach, are continuous with the plexus of ultimate fibrillæ of the gray matter. Some of the bundles cross to the opposite side of the cord in the anterior white commissure. A *median*, a *lateral*, and an *intermediate* group are recognized.

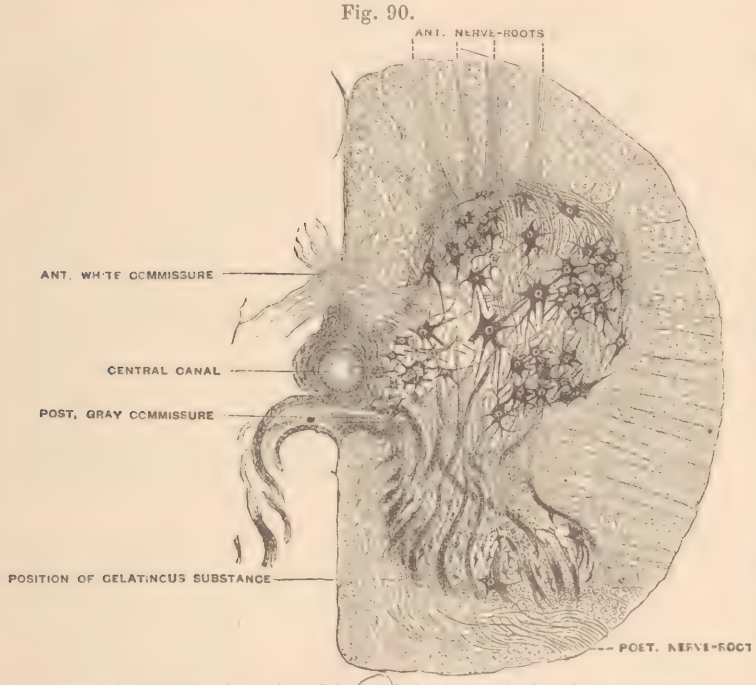
The posterior nerve-roots, after entering the postero-lateral fissure, disperse and tend to be deflected medianly through the postero-lateral column, and, at the border of the gelatinous substance, form a plexus. The ultimate course of the posterior nerve-roots is

[1] The following is the original description of this column by Goll (Denkschr. der medico.-chir.Gesellschaft. des Kantons Zürich, 1860, 130, figs.): "On the posterior column is a small wedge-shaped lobe, limited medianly by the longitudinal fissure (septum), and laterally by the posterior horn. Within this column in the cervical region the observer can detect with the unaided eye a dark wedge-shaped median portion, the base of which is posterior, and the apex of which is situated one-half mm. from the posterior commissure."

not known. They probably end in the plexus of Gerlach, and some terminate in the nerve-cells at the cervix cornu. (Fig. 90.)

The spinal cord as a bilateral structure.—Bilaterality is early announced in the spinal cord. The columns of white matter are separated in different degrees—the antero-lateral columns being further apart than the posterior. Transverse commissural fibres unite those parts which have widely diverged from one another. The most conspicuous of the transverse fibres serve to unite the antero-lateral columns. The central portions of gray matter which remain undifferentiated into right and left parts are also called commissures. This use of the term is purely conventional.

Fig. 90.



A semi-diagrammatic section of the left half of the spinal cord, showing the arrangement of white and gray matter and the central canal.

Relations.—The spinal cord, although lodged within the vertebral canal, does not fill it. Between the cord and the walls of the canal is a large space which contains a clear fluid, loose connective tissue, and a few minute bloodvessels. The cord hangs in the vertebral canal, and retains a considerable degree of mobility. It is more closely connected to the bodies than to the arches of the vertebræ.

The spinal cord, with the exception of the terminal filament, as already seen, lies within the cervical and lumbar portions of the vertebral canal. The cervical enlargement is widest behind the sixth cervical vertebra; the lumbar behind the eleventh dorsal vertebra; and the *conus medullaris* behind the body of the twelfth dorsal vertebra.

The apparent origins of the spinal nerves may be appropriately included among the relations of the cord. For their full consideration, see Spinal Nerves.

The Ligaments of the Spinal Cord.—The cord is surrounded by a sheath composed of membranes which are continuous with those of the brain, and which have received the same names, the pia mater, the dura mater, and the arachnoid.

The *pia mater* is often called the vascular coat, since within it lie the bloodvessels of the cord. It is composed of delicate connective tissue, which penetrates the fissures of the cord, and sends processes from the periphery to the dura mater, along the paths of exit of the spinal nerves. Of these processes the first is the largest, and is found opposite the margin of the foramen magnum, between the vertebral artery and the hypoglossal nerve. The remaining processes vary in number from eighteen to twenty and are lodged between pairs of spinal nerves. The entire series has received the name of the *denticulate ligament* (ligamentum denticulatum) in allusion to the tooth-like character of the processes.[1] They are arranged in two perpendicular rows, one on each side of the cord.—The pia mater accompanies the terminal filament to the end of the vertebral canal. In aged subjects it is of a light gray or brownish tinge.

The *dura mater* is a firm stout membrane adherent to the margin of the foramen magnum above, and attached to the coccyx below. It is surrounded by a quantity of soft fat, and is pierced at the sides for the escape of the spinal nerves, the fibrous covering of each nerve being continuous with that of the spinal cord. The dura mater is adherent by fibrous tissue to the posterior vertebral ligament.

The *arachnoid membrane* is not in such intimate relation with the pia mater as is the case within the skull; a comparatively large subarachnoid space filled with serum is demonstrable, through which may be traced various nerve-roots, vessels, and fine bundles of connective tissue.

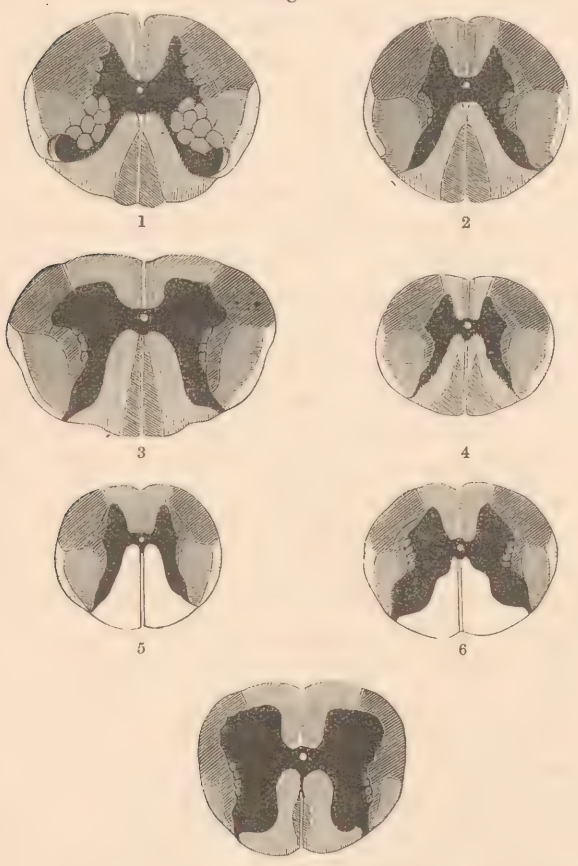
The Development of the Spinal Cord.—The walls of the central canal, the gray matter, and the posterior median columns, in part, are derived from the epiblast; the neuroglia and the nerve-fibres from the mesoblast.

[1] Some authorities have described the denticulate ligament as distinct from the pia mater.

The cord, as first announced, is composed chiefly of the epiblastic elements, and exists as a shallow depression in the medullary groove. This groove deepens, the sides approximate, and, toward the dorsal surface, form *the postero-median fissure*, thus cutting off the lower or central portion of the groove and converting it into a canal. The gray matter is next developed about the walls of the groove, the nerve-fibres being subsequently adapted to its conformation.

Development of the cord furnishes data by which the longitudinal fibres can be divided in a manner somewhat different from that which is practicable by the study of the cord after birth. P. Flechsig[1] determines the anterior column to be composed of two portions—a median and a lateral; the lateral column being composed of an anterior, a posterior, and a lateral portion. The last portion, from the fact that it can be traced to the cerebellum, has received the name of the *cerebellar tract;* while the postero-median column, instead of being restricted to the cervical and upper portion of the cord, can be clearly seen passing along the median aspect of the postero-lateral column as far as the lumbar enlargement. An additional column lies directly to the outer side of the gray matter.

Fig. 91.



A series of transverse sections of the spinal cord arranged from above downward, showing the subdivision of the columns as defined by the facts of development.

Spaces shaded ═══, antero-median and posterior portions of the lateral columns; ▨ antero lateral columns; ⁞⁞ cerebellar tracts; ||| postero-lateral columns; ▨ postero-median columns. The black surface represents the gray matter. 1, 2, 3, from the cervical portion; 4, 5, from the dorsal portion; 6, 7, from the lumbar portion.

[1] Die Leitungsbahnen im Gehirn und Rückenmark des Menschen, etc., Leipzig, 1876.

The several parts of these columns of nerve-fibres appear in the following order:—

First, the region of the exit of the fibres of the anterior nerve-roots and the antero-lateral column at the fourth week; second, the postero-median columns and the cerebellar tracts at the third month; third, the median part of the anterior columns, together with the posterior part of the lateral columns, at about the fifth month.[1]—The last-named parts, since they constitute the anterior pyramids of the medulla oblongata, are generally called the *pyramidal tracts.* The fibres of decussation in the pyramids are traceable into the posterior part of the lateral column, which thus becomes the *crossed pyramidal tract;* while the fibres in the pyramids which pass into the lateral part of the anterior column without decussation form the *direct pyramidal tract.*

Flechsig[2] traces the paths in the spinal cord, already outlined, upward into the brain as follows:—

The direct pyramidal and crossed pyramidal columns continue up through the anterior pyramids of the medulla oblongata, the pons Varolii, and the crura cerebri to the striated body, and through the ganglia and nerve-fibres of this mass to the medullary matter of the cerebrum, and thence to the cortex of the anterior portion of the cerebrum. The cerebellar tracts end in the cerebellum. The gray columns are continuous with the gray matter of the medulla and the pons to the lower origin of the crura cerebri, and thence by the tegmentum to the thalamus.—(For details and practical application of these facts, see Brain.) V. P. Gibney[3] reports a case of compression of the cord, in which the cerebellar tracts and the postero-median columns could be easily discerned with the aid of a low power.

[1] Since statements by some authorities, *e. g.*, Grasset (Traité pratique des Maladies du Système Nerveux, 2d edition, 1881) and Quain (Anatomy, 9th edition, 1882), do not agree in all particulars with the above, it may be well to state that the data have been derived from Flechsig, last quoted, p. 192.

[2] Archiv für Heilkunde, 1877, xviii. 101, Taf. vi.

[3] Amer. Journ. of Neurology and Psychiatry, 1882, i. 490.

From the fifth month of intra-uterine life until birth, the cord increases in length about a centimetre a month. At birth the spinal cord ends at the level of the third lumbar vertebra. The postero-median columns are much more conspicuous, according to Eichorst,[1] before than after birth, and are best studied at about the third month.

The *bloodvessels of the spinal cord.* The *arteries*, as already noticed (p. 375), are derived from the spinal, the intercostal, the lumbar, and the vertebral. The main vessel, the antero-spinal artery, lies on the periphery at the antero-median fissure, but a number of arterioles (*centripetal branches*) penetrate along the postero-median fissure, and in some of the large radiate septa, in the direction of the gray matter. Branches of the anterior spinal artery (*centrifugal branches*)[2] pass off at right angles from the vessel as far as the level of the anterior white commissure.—It is interesting to remark that the subdivision of the nerve-fibres by embryological and clinical tests above noted is sustained by the characterization of the capillary network.[3] An open meshed capillary network exists among the nerve-fibres; but a more closely set polygonal network among the nerve-cells. The capillary plexuses in the antero-median columns are wide-meshed; in the lateral columns they are of medium size; while they are narrowest in the posterior column: a difference can even be detected between the meshes of the networks of the postero-median and the postero-lateral columns.

A central artery, as defined by Jas. Ross,[4] penetrates the gray matter a little to the outer side of the central canal, and divides into an anterior, a posterior, and a median set of branches.

According to Moxon,[5] minute branches of the intercostal, lumbar and vertebral twigs pass upward along the nerve-roots. But toward the lower end of the cord the supply from all sources is diminished, and the dangers at this place arising from interference with blood-supply are hereby increased.

The *central veins* are two in number. They extend a little to the outer side of the central canal in the *substantia reticularis*. At both the superior and the inferior end of the cord each vein ends in from eight to ten branches.

[1] Virchow's Archiv, 1875, lxiv. 425.

[2] Adamkiewicz, Über die Microscopisch-Gefässe des menschlich. Rückenmarks. Trans. Internat. Med. Congress, 1881, i. 155; also Wiener Sitzungsberichte, 1881, iii. 107.

[3] W. Krause, Handb. der menschlichen Anat. von C. F. T. Krause, 1876, i. 400.

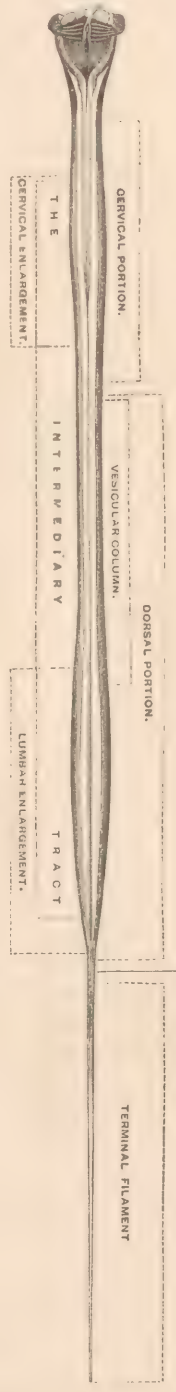
[4] Brain, 1880, iii. 80.

[5] Lancet, 1881, 529.

Lymph.—Quincke[1] has detected a to-and-fro circulation of lymph-fluid in the arachnoid membrane while under the influence of respiration. The fluid is continually being secreted, so that when lost by a lesion of the membrane it can be re-established.

The accompanying figure and table will aid the reader in localizing the various structures in the spinal cord.

Fig. 92.



Extends from the third or the fourth cervical vertebra to the third dorsal vertebra. Contains cilio-spinal centres—the white and gray matter is of equal bulk. Injury of the enlargement may induce diabetes.

Extends from upper border of the atlas to the third dorsal vertebra. Anterior median column and postero-median column form part of the cortex. Postero-median fissure conspicuous. Intermediary fissure present.

Extends from the third dorsal vertebra to the first lumbar vertebra. The grooves between the places of exit of nerves absent. The posterior median fissure inconspicuous. The gray matter of the posterior commissure twice the thickness of the anterior.

Extends from the lower border of the tenth dorsal vertebra to the first lumbar vertebra. Contains the genito-spinal and the ano-spinal centres.

Conus Medullaris.

Composed of gray matter and neuroglia. Gives off no nerves. Contains no central canal.

[1] Archiv für Anatomie, 1872.

Variations.—The degree to which the fibres decussate in the anterior pyramids of the medulla oblongata is subject to great variation. Flechsig[1] found that, while to the naked eye the difference between the points at which the anterior columns of the spinal cord join the medulla is inconspicuous if not indiscernible, a study of the minute structure may show great variations to exist in the size of the crossed and direct tracts. In making a transverse section of the spinal cord of a newly born child, at the level of the second cervical nerve, and comparing it with a similar section made from another subject of the same age, he found that in one the antero-median column had received most of the fibres, while in the other the postero-lateral had received the greater number. In the first-named section, most of the fibres were direct, having passed for the most part by the antero-median column; while in the other they were crossed or indirect, since they were for the most part found in the posterior part of the lateral column.[2]

The groove separating the anterior column from the lateral column, and the groove between the postero-median and the postero-lateral column, often persist up to the eighth year, and may in rare instances be found in the adult.

It has been already noted (General Considerations) that both congenital and acquired defects of the limbs will modify the volume of the gray matter controlling the muscles of the affected limbs. The study of the variations in the amount and arrangement of the several parts of the gray matter of the spinal cord, therefore, should always embrace the study of the regions controlled by the gray matter. Pitres[3] found marked changes in the motor cells of the spinal cord in a case of congenital *talipes equino varus*. Israel[4] found, in a case of old gunshot injury of the median and ulnar nerves of the left side, the corresponding portion of the middle and lower portions of the cervical division of the cord much smaller than those of the right.

Fürstner and Zacher[5] found traces of a double spinal cord in a single axis normally related to its membranes and to the vertebral canal.

Remarks.—The different segments of the spinal cord can be limited for practical purposes in three different ways, as follows:—

(1) By the position of the bodies of the vertebræ: thus, the cervical, the dorsal, and the lumbar portions are recognized. This plan, however, lacks exactness, since the cervical enlargement extends from the region of the neck behind the body of the first dorsal vertebra, and the lumbar enlargement begins behind the body of the twelfth dorsal.

(2) By the distance from the conus medullaris, expressed in lines or centimetres.

(3) By the points of apparent origin of the spinal nerves.

In describing the location of a given morbid change or of an injury, advantage might be derived from employing all these methods.

The cerebro-spinal axis of insects, crustaceans, and allied creatures exhibits a series of connected ganglia from which arise the spinal nerves; these are thought to correspond in number to the segments composing the body. In vertebrates, traces of a similar arrangement are detected. Best seen in the fish and the serpent, they are discernible in the rabbit, and exist in the form of elliptical swellings corresponding in number to the vertebræ and to the attachment of the roots of the spinal nerves. In the human subject, as already noted, these swellings are two in number, and represent, it is thought, the aggregation of several spinal segments. The spinal cord in the dorsal region exhibits, in the intervals between the origins of the nerves, points at which, in the judgment of C. Lüderitz,[1] the segments of the human cord may be said to join.

The apparently homogeneous medullary substance is known (see Development) to be composed of a number of bundles of distinct origin. In the spinal cord of the adult no traces remain of these origins, but in the invasion of disease they may again be demonstrated. Clinical observers have noticed that portions of a fresh specimen of a spinal cord, suspected to be the seat of diseased action, after immersion in a two-per-cent. solution of bichromate of potash and after preservation in alcohol, will exhibit the diseased regions of the cord in the form of bright yellow tracts—the unaffected portions of the cord becoming of a dark yellow hue. The bright yellow tracts are under certain conditions, such as in active connective-tissue proliferations, slightly wider than the tracts that are actually degenerated, but within such limitation the test is one of clinical value.—Such appearances must not be confounded, according to P. Schiefferdecker,[2] with the diffused areas of de-

[1] Die Leitungsbahnen im Gehirn und Rückenmark des Menschen, etc., Leipzig, 1876, 321.

[2] Archiv für Heilkunde, 1877, xviii. 333, Taf. ix.

[3] Archiv. de Neurolog., June, 1882.

[4] Virchow's Archiv, lxxxv.

[5] Archiv für Psychiatrie und der Nervenkrankheiten, 1882, xii. 373.

[1] Archiv für Anatomie und Physiologie, 1881, 423.

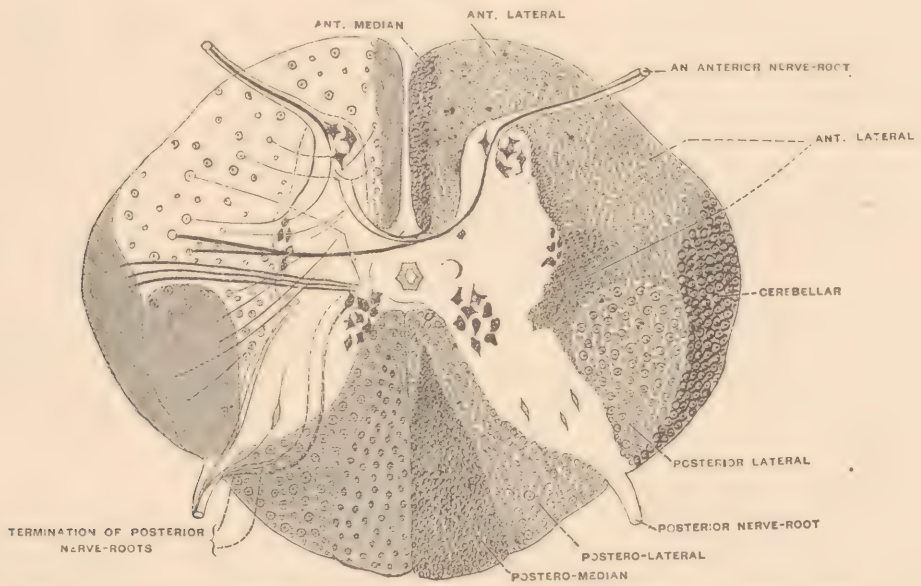
[2] Virchow's Archiv, Bd. 67, 1876, 572.

generation which spread a short distance on either side of a wound of the spinal cord.

Dr. Jas. Ross,[1] in alluding to the arrangement of cells in the spinal cord, uses the following suggestive language:—

"It may be readily imagined that in all inflammatory diseases the vicinity of vessels will be more liable than the remote portions to be inundated by effusion, hence the lines of distribution of the vessels may be said to form lines of least resistance to disease. It is also worthy of remark, that the development of the cells proceeds from the centres of the groups to their margins, and that in progressive degenerative diseases the degeneration proceeds from the margins of the groups to their centres. To this law the median area in the lumbar, and more especially in the cervical enlargement, and that which lies between the antero-lateral and postero-lateral groups in the dorsal and upper cervical regions, are apparent exceptions. These areas, although containing cells, can hardly be called groups; they are probably areas where the marginal cells of the real groups meet. But, whatever may be their nature, they are the most vulnerable portions of the cord, and as they are the last developed, so they manifest the greatest liability to disease"

Fig. 93.



A diagrammatic transverse section of the spinal cord, designed to exhibit the localization of diseased action. The shaded columns to the left indicate, at the antero-median and the light-dotted area to the outer side of the posterior nerve-roots, the tracts of centrifugal degeneration and various forms of sclerosis. The postero-lateral and postero-median columns are affected in locomotor ataxia. The white spaces free from nerve-fibres represent the gray matter, and are involved in myelitis and various forms of sclerosis. The irregular lozenge-shaped figures in the white spaces represent groups of nerve-cells On the left of the figure, as shown in order from the top to the bottom of the figure, are represented: the origin of some of the motor nerve-fibres; a decussating fibre destined for an anterior nerve-root of the right side; horizontal fibres uniting the vesicular and cerebellar columns; fibres of the posterior nerve-root.

The *localization of diseased action* in the spinal cord may be studied within the neuroglia, the gray matter, and the medullary matter.

When the effects of diseased action are restricted to the *neuroglia*, they are called *diffuse* or *interstitial*. Such lesions are of course liable to affect the neuroglia at any part, but may be especially well seen in the *substantia reticularis* and the peripheral portion.—When the effects of diseased action are restricted to the anatomical and physiological tracts of gray and white matter, they are called *systematic* or *parenchymatous*. But in long-standing disease an interstitial point of change may involve a systematic tract, as one originating in a systematic tract may secondarily involve an adjacent area of neuroglia.

The postero-median fissure being for the most part a connective-tissue septum, it is easily seen why a degenerative change beginning in the postero-median column of one side may finally involve the column of the same name of the opposite side. In like manner, a morbid process, originating in the nerve-cells, may involve the gelatinous substance. Such instances of irregular diffusion along connective-tissue lines must not be confounded with parenchymatous changes.

The *systematic* localization embraces (1) diseases of the gray matter; (2) diseases of the medullary matter.

[1] Brain, 1880, iii. 80.

(1) When nerve-cells of the anterior gray column are involved, as in inflammatory conditions, the characteristic lesions of infantile spinal paralysis, spinal paralysis of adults, and pseudo-hypertrophic spinal paralysis ensue. — In a special form of atrophic change in the cells of gray matter at the upper part of the spinal cord, which involves the fibres of origin from the hypoglossal, the lower facial, the spinal accessory and the pneumogastric nuclei, the lesions of glosso-labio-laryngeal paralysis are seen.—Eulenberg and Cohnheim[1] found atrophy of the cells of the left anterior horn of the lower part of the lumbar enlargement—the right being normal—in a case of infantile paralysis in a child dying at fifteen years. Marked deformation of the vertebral column and *pes varo-equinus* had existed during life.—Cornil[2] found, in a woman aged forty-nine, who had been paralyzed in the lower extremities from early childhood, the dorsal portion of the spinal cord atrophied, and studded throughout the gray matter with centres of amyloid degeneration, with similar involvement of the white matter. The left ischiatic nerve was smaller than the right, and the left peroneal nerve was atrophic.

(2) The systematic effects of diseased action of the medullary matter are more numerous than those of the gray matter, and are quite as well defined. It has been found, for example, that the different portions of the spinal cord, as determined by Flechsig, answer to the tracts of development, and that they are liable to be separately attacked by disease either primarily or secondarily to the destruction of the continuity of the fibres. Thus the antero-median column (the direct column of Türck), or, the columns at the posterior portion of the lateral column (crossed columns of Türck), are known to become degenerated as sequelæ to disease of the cerebrum (q. v.). Such degeneration, occurring as it does from the brain outward, is called *centrifugal* or *descending*. The degree in which a tract of degeneration, beginning in one cerebral hemisphere, involves the side opposite to it in the spinal cord, is determined by the number of decussating fibres in the anterior pyramids of the medulla. In like manner, injury or disease involving the postero-lateral columns causes secondary degeneration to take place from below upward, and is known as *centripetal* or *ascending*. Ascending degeneration is apt to involve by continuity of connective-tissue the postero-median columns, as already noted. — The postero-median column, according to A. Pierret,[1] may, however, be independently affected in locomotor ataxia. This author recognizes a clinical subdivision of the postero-lateral column. He denominates the median portion the "*ruban interne*," and the lateral portion the "*ruban externe*," and claims that each of these parts may become separately diseased.

In descending degeneration along the pyramidal tracts, according to E. Brissaud, the motor cells of the anterior horns in connection with these tracts, the gelatinous substance, and the intermediary tract of cells, undergo atrophy.

It is evident that the paths of degeneration will vary as the normal tracts themselves do, and that a correct knowledge of the systematic lesions of the cord is dependent upon what is known of the variations of the arrangement of the nerve-fibres.[2]

The following centres have been located by physiologists in the spinal cord.

The *cilio-spinal centre*. It lies between the roots of apparent origin of the seventh cervical and the third dorsal vertebra —The *genito-spinal centre*. It lies in the lower part of the lumbar enlargement.—The *ano-spinal centre*. It lies at the lowest part of the lumbar enlargement.

W. Müller[3] narrates an interesting case in which diabetes, accompanying atrophy of gray matter of the spinal cord, followed fracture of the seventh cervical vertebra.

[1] Comptes Rendus et Mém. de la Soc. de Biol., 1866, xvii. 215.
[2] Ibid. 1883, v. 187.

[1] Arch. de Phys. normale et pathologique, 1871–72, iv. 364, figs.
[2] The reader will find this subject discussed by Türck, Sitz. Wien., 1853, xi. Heft. 1; P. Flechsig, Die Leitungsbahnen im Gehirn und Rückenmark des Menschen, etc., Leipzig, 1876, pp. 382, numerous figures; P. Schieffendecker, Virchow's Archiv, 1876, lxvi. 542, figs.; and P. Flechsig, Archiv der Heilkunde.
[3] Beiträge zur Patholog. Anatomie u. Phys. des Mench. Rückenmark, Leipzig, 1871, 35, Taf. ii. fig. 6.

The respiratory centre is thought by some to extend into the cervical portion of the cord. The fact that this centre is continuous with the main centre of the same name on the floor of the fourth ventricle, and that the remaining cervical centres control areas which are limited by the head and face, warrant observers in concluding that the spinal centres in the neck are in close relation to the encephalic centres. In an exact sense the encephalon may be said to end at the cervical enlargement or at the lower limit of the postero-intermediary grooves.

THE BRAIN.

THE Brain (encephalon) is that portion of the cerebro-spinal axis which is lodged in the brain-case.

The parts of the brain will be presented in the following order, tracing the relations of the structures, for the most part, from below upward.

Hind Brain	Medulla Oblongata.
	Pons Varolii.
	Cerebellum.
Mid-Brain	Crura Cerebri.
	Corpora Quadrigemina.[1]
	Pineal Gland.
Fore-Brain	Cerebrum.

The Base of the Brain.

Minute Anatomy.
Bloodvessels.
Variations.
Development.
Relations.

THE MEDULLA OBLONGATA.

The Medulla Oblongata (Plate LXXX., fig. 6; Plate LXXXII., figs. 2 and 4; Plate LXXXIII.) (mydencephalon, bulbus rachidicus) is situated between the spinal cord and the pons Varolii. It lies upon the basilar groove of the occipital bone, and above is received within a depression on the under surface of the cerebellum, termed the *vallecula*.

It is of an oblong shape, broader above than below, and is slightly compressed from before backward. Its posterior surface is flatter than the anterior, and assists in forming the floor of the fourth ventricle. The medulla oblongata measures one inch and a quarter in length, one inch in width, and half an inch in thickness at its thickest part. It gives origin to the cranial nerves from the seventh to the twelfth.

A detailed account of the medulla oblongata embraces the consideration of the external configuration and the topography of the fourth ventricle.

[1] The tract which, in a transverse (frontal) section, includes sections of the corpora quadrigemina and the communicating passage between the third and fourth ventricles, has received the name of the *stem* or *isthmus of the brain*. This tract is usually described after the cerebellum, but inasmuch as the relation of its structures can be best understood after the cerebrum is described, the account of the tract will follow that of the cerebrum.

The general configuration of the medulla recalls that of the spinal cord, inasmuch as it presents an anterior and a posterior median fissure. In addition it presents an anterior and a posterior surface. The anterior surface is marked by the *anterior pyramids*. These are two elongated bodies situated on either side of the median fissure, broad above, narrow below, and slightly contracted just before passing into the pons Varolii. The anterior pyramids do not answer exactly to the anterior columns of the spinal cord, since many of the fibres composing the pyramid of one side are derived from the lateral columns of the opposite side. The intercrossing of these fibres constitutes the decussation of the anterior pyramids.—The name of *olivary body* is given to an elliptical mass situated between the anterior pyramid and the restiform body. This body possesses within its interior a nucleus, termed the *dentate body*, which resembles a pouch open in front, and which has plicated borders. The dentate body, to anticipate here the account of the minute anatomy of this structure, yields a fasciculus, which, passing up through the pons, contributes to the formation of the fillet.

Extending across the anterior surface of the medulla, immediately below the olivary bodies, is seen a group of delicate fasciculi, known as the *arciform fibres*. This group forms part of a system of transverse fibres which will be described under the head of the minute anatomy of the brain.

The *restiform body* is situated to the lateral (outer) aspect of the medulla, having the olivary body to its median (inner) side. It is the continuation, in great part, of the lateral column of the spinal cord. Above it is continuous with the inferior peduncle of the cerebellum. It also sends a large bundle of fasciculi posteriorly to form the *fasciculi teretes* of the fourth ventricle.

The *posterior pyramids* aid in defining the lateral boundaries of the lower or medullary part of the fourth ventricle. The median portion of each pyramid has received the name of the *funiculus gracilis*. It is thin, and diverges from its fellow of the opposite side. The upper end of this funiculus is called the *clava*. The lateral portion of each posterior pyramid is marked by the *funiculus cuneatus*.—Between the

posterior pyramids lies the upward continuation of the posterior intermediary fissure of the spinal cord.

Directly to the inner side of the posterior pyramid, and developed in the epithelial roof of the fourth ventricle, is an exceedingly delicate fasciculus, named the *ligula*. Above, at the termination of the posterior pyramid, it is continuous with the restiform body, and joins its fellow of the opposite side at the posterior median fissure, by means of a delicate commissure-like band called the *obex*.

The Fourth Ventricle is the space bounded in front and below by the posterior surface of the medulla oblongata and the region of the pons; above by the inferior vermiform process of the cerebellum and epithelium; laterally, above the centre, by the converging superior peduncles of the cerebellum; and below, by the diverging posterior pyramids. The cavity of the ventricle is continuous above with the passage between the third and fourth ventricles, and below with the central canal of the spinal cord. It presents a roof or upper surface, a floor or lower surface, and lateral walls.

The vaulted *roof* presents the uvula and the nodule of the cerebellum, in addition to the epithelial structures above described. The opening between the cerebellum and the medulla oblongata—often called the *inferior transverse fissure*—is occupied by an epithelial membrane and pia mater which effect entrance into the fourth ventricle in the form of a vascular tuft. The arachnoid membrane is perforated as it lies in this fissure to form the *foramen of Majendie*, which permits the subarachnoid fluid to enter the fourth ventricle.

The *floor of the fourth ventricle* is an uneven rhombic surface, presenting an anterior angle, a posterior angle, and two lateral angles. The anterior (superior) angle is formed by the convergence of the superior peduncles of the cerebellum. The posterior (inferior) is formed by the divergence of the fasciculi graciles. The floor is marked by a longitudinal median line, on either side of which the structures are arranged symmetrically. Adjoining the groove is a conspicuous fusiform swelling, the *fasciculus teres*. Its posterior extremity narrows, and forms, with its fellow of the opposite side and the ligulæ, the *calamus scriptorius*. Upon the outer side of the calamus is a dark point called the *ala cinerea*, while directly upon the fasciculus teres is a bluish spot, termed the *locus cæruleus*. Extending across from the median groove, at the position of the lateral angles, to the outer boundary of the restiform body, is a set of transverse fibres of origin of the auditory nerve, known as the *striæ acousticæ*. Below these are small imperfectly defined eminences for the nuclei of the acoustic and hypoglossal nerves.

The *lateral walls* do not demand separate description.

THE PONS VAROLII.

The Pons Varolii[1] (Plate LXXX., fig. 4; Plate LXXXIII.) (tuber annulare), is that portion of the brain situated between the medulla oblongata and crura cerebri. It is a cuboid mass of white fibres which serves to unite, by means of the middle peduncles of the cerebellum, the lateral masses or hemispheres of that body. Its size bears a constant relation to that of the cerebellum, in the congenital absence of which it is wanting. Its fibres slightly converge toward the somewhat arched lateral margin. In the middle line it is marked by a longitudinal groove, for the basilar artery. At its posterior portion the pons is slightly elevated. The anterior third of the lateral margin is penetrated by the roots of apparent origin of the fifth nerve.

THE CEREBELLUM.

The Cerebellum (Plate LXXX., figs. 2, 5, 6; Plate LXXXII., fig. 2; Plate LXXXIII.), or lesser brain, is lodged between the medulla oblongata and the posterior portion (occipital lobe) of the cerebrum. When the encephalon is in position the cerebellum lies in the occipital fossa of the occipital bone. Beneath, and somewhat in front of the cerebellum, lies the fourth ventricle.

The plan of the cerebellum is that of a median portion (central lobe), united to a pair of lateral masses (hemispheres). The entire mass of the cerebellum is of compressed ovoidal form, with its longest diameter transverse to the antero-posterior diameter of the encephalon. Both upper and lower surfaces are convex; the upper being somewhat inclined downward and backward, and the lower slightly swollen toward the outer sides. The cerebellum measures $3\frac{1}{2}$ to 4 inches transversely, 2 to $2\frac{1}{2}$ inches antero-posteriorly, 2 inches in thickness. The average weight is $5\frac{1}{4}$ ounces.

The median portion is shorter than its related masses, so that a notch is formed in front, within which is received the posterior part of the corpora quadrigemina, and behind is lodged the falx cerebelli. The upper surface of the median portion is slightly raised above the level of the hemispheres,

[1] The pons Varolii and the cerebellum constitute the metencephalon.

but the lower surface is depressed to form the *vallecula*, which receives the medulla oblongata. The laminæ of the median portion are continuous with those of the hemispheres. They describe a series of arcs or abrupt curvatures peculiar to their situation. The rude resemblance which these bear to the annulations in a worm has caused the median portion to be divided into a *superior* and an *inferior vermiform process*, which are continuous with one another. Unimportant subdivisions of the vermiform processes are given by writers. Thus the superior vermiform process is marked, from before backward, by the *central lobe*, the *monticulus*, and the *posterior commissure*; and the inferior, by the *nodule*, the *uvula*, the *pyramid*, and the *tuber valvulæ*.

Each hemisphere is divided into two unequal parts by *the great horizontal sulcus*, which extends from the point of junction of the middle peduncle with the lateral mass backward to the outer border of the hemisphere. Below, the surface is subdivided into a number of lobules of unknown function, which have been named the *posterior inferior*, the *slender*, the *bi-ventral* (digastric), the *pneumogastric* lobe, the *flocculus* or sub-peduncular lobe, the *furrowed band*, and the *tonsil* (amygdala). See figures on Plates LXXX., LXXXII.

The *tonsil* is a rounded, well-defined lobe, situated between the posterior inferior, slender, and digastric lobes on its outer side, and the posterior notch on the inner side. The *flocculus* is a slender acuminate lobule, composed of five or six small folia, and containing a lateral diverticulum of the fourth ventricle, with which it communicates below the middle peduncle. In this respect it recalls the form of the cerebellar lobes, as seen in fishes. Upon the peduncular side of the flocculus a small tuberculated or foliated appendage is seen, which Henle describes as the *associated flocculus*. The *furrowed band* lies concealed beneath the tonsil. It is connected with the inferior vermiform process, from which it passes obliquely backward and outward. The flocculus and furrowed band are not embraced within the general outline descriptive of the lateral mass. The *anterior medullary velum* (valve of the fourth ventricle, valve of Vieussens) is the name given to a thin lamina of medullary substance extending across the central canal between the fourth ventricle and the beginning of the *iter*. Its upper surface is marked by a thin projection of the cortical substance of the cerebellum, marked by five or six transverse folds, called the *lingula*.—The *posterior medullary velum* is a symmetrical lunate lamina stretching across the fourth ventricle from the median to the lateral portions of the cerebellum, *i. e.*, from the sides of the uvula and nodule to the tonsils.

The surfaces of the cerebellum present large numbers of laminæ or folia, which bear a superficial resemblance to the convolutions of the cerebrum, inasmuch as each pair of laminæ represents an eminence with a sulcus or depression on each side. The hemispheres are aggregations of laminæ or folia, and each lamina is furnished with numbers of corrugated folds of various sizes.

The cerebellum is connected with the medulla oblongata and the cerebrum by the inferior and superior peduncles, while the two hemispheres of the organ are united by the conspicuous middle peduncle.—The *inferior peduncles*[1] are the continuations upward of the outer portions of the restiform body. They are lost in the lower posterior portion of the cerebellum. The *superior peduncle*[2] passes from the cerebellum, at the nucleus dentatus, upward toward the corpora quadrigemina, beneath which it passes to join the tegmentum of the crus cerebri. Extending across between the portions of the cerebellum, and constituting the anterior surface of the pons Varolii, is the *middle peduncle*.[3] It is composed of a superficial and a deep set of fibres, beneath and between which pass the nerve-fibres uniting the cerebrum, corpora quadrigemina, and the medulla oblongata.—Both the superior and the inferior peduncles are tracts of great importance in the transfer of impressions from the spinal cord to the cerebrum, while the middle peduncle may be regarded in the light of a commissure uniting the lateral portions of the cerebellum.

The other nuclear aggregations of nerve-cells in the deeper structures of the cerebellum are named the *nucleus emboliformis*, the *nucleus globosus*, and the *nucleus fastigii*. These are related to the dentate body. The *nucleus fastigii* is thought to be the most important of these nuclei. It is the nucleus of the roof of the fourth ventricle, and is that portion of the cerebellum supposed to suffer to the greatest extent from diseased action or lesion.

The Cerebrum.

The Cerebrum is by far the largest part of the brain. It is composed of two hemispheres, separated

[1] Myelobrachium (Spitzka); post-pedunculus (Wilder).

[2] Anterior peduncle, brachium conjunctivum; tegmenta brachium (Spitzka); præpedunculus (Wilder).

[3] Pontibrachium.

for the most part by the great longitudinal fissure, but united below by the corpus callosum.

The figure resulting from the union of the hemispheres is half ovoidal, the base being beneath and the narrower end directed forward. The cerebrum is convex above and at the sides, but partially concave beneath; for, while the anterior and the middle basal surface of each hemisphere is convex, the posterior portion is concave. The occipital lobe of the left hemisphere is longer and narrower than that of the right. The cerebrum is more or less accurately conformed to the general shape of that portion of the brain-case within which it lies, excepting the postero-inferior portion, which rests upon the *tentorium cerebelli*.

The description of the cerebrum will include—

I. The External Surface or Periphery.

II. The Structures embraced within the Cerebrum.

I. THE EXTERNAL SURFACE OR PERIPHERY.

When the two cerebral hemispheres are in position, the fissure separating them is named the *longitudinal fissure*, and receives the great longitudinal falx of the dura mater. When the cerebrum and the cerebellum are in position, the fissure which separates them, and which at the same time is continuous with the lateral and third ventricles, is named the *transverse fissure* (superior transverse fissure, fissure of Bichat), and receives in part the tentorium. The external surface of each cerebral hemisphere is composed of a number of delicate laminæ of nerve-cells and nerve-fibres, which in the main present to the unaided eye the appearance of a single layer of gray matter. This surface is termed the *cerebral cortex*, and is marked by a great number of depressions, which define the outlines of rounded worm-like figures. The depressions are called the *cerebral fissures* or *sulci;* and the worm-like elevations the *cerebral convolutions* or *gyri*. Each fissure possesses a depth of about one-half to one inch, and is occupied by a process of pia mater.

The cerebral fissures are of varying degrees of significance. When a number of them are found to be constant, or to answer to more deeply seated cerebral structures, they may be said to constitute the *main fissures*, and are used in dividing the external surface into lobes or regions.

Each cerebral hemisphere presents a *lateral* (outer) *aspect*, a *basal* (under) *aspect*, and a *median* (inner) *aspect*. The lateral and basal aspects are continuous by a broad rounded border, which, by reason of the fissures and convolutions passing freely from one to the other, cannot be separated at all points. The median aspect is more distinct. Each hemisphere presents in addition a *superior median border* where the lateral and median aspects join.

Each hemisphere is again divided into a frontal, a parietal, an occipital, a temporo-sphenoidal, and a central *lobe*.

THE MAIN CEREBRAL FISSURES AND CONVOLUTIONS.—Under this head will be described the main cerebral fissures and such convolutions as lie adjacent to them.

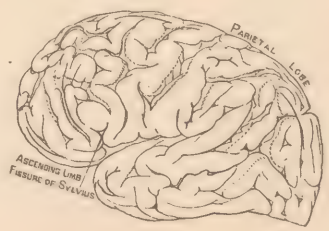
The main cerebral fissures are—

(1) The Fissure of Sylvius.
(2) The Fissure of Rolando.
(3) The Parieto-Occipital Fissure.
(4) The Calcarine Fissure.
(5) The Hippocampal Fissure.
(6) The Olfactory Fissure.
(7) The Collateral Fissure.

EXPLANATION OF PLATE LXXIX.

Fig. 1. Dorsal aspect of the left cerebral hemisphere. The median border answers to the lower margin of the figure.

Fig. 2. Lateral aspect of the left cerebral hemisphere. The convolutions have not been successfully reproduced, necessitating an additional figure on Plate LXXXI. It exhibits, however, in a satisfactory manner, the usual disposition of the fissure of Rolando, together with good views of the parieto-occipital and Sylvian fissures. The "parietal lobe" should be limited to the region between the "fissure of Rolando" and the "parieto-occipital fissure." For "inter-parietal sulcus," read "intra-parietal sulcus." Herewith is appended a reduced outline of Fig. 2, with the more important of the above errata graphically corrected.



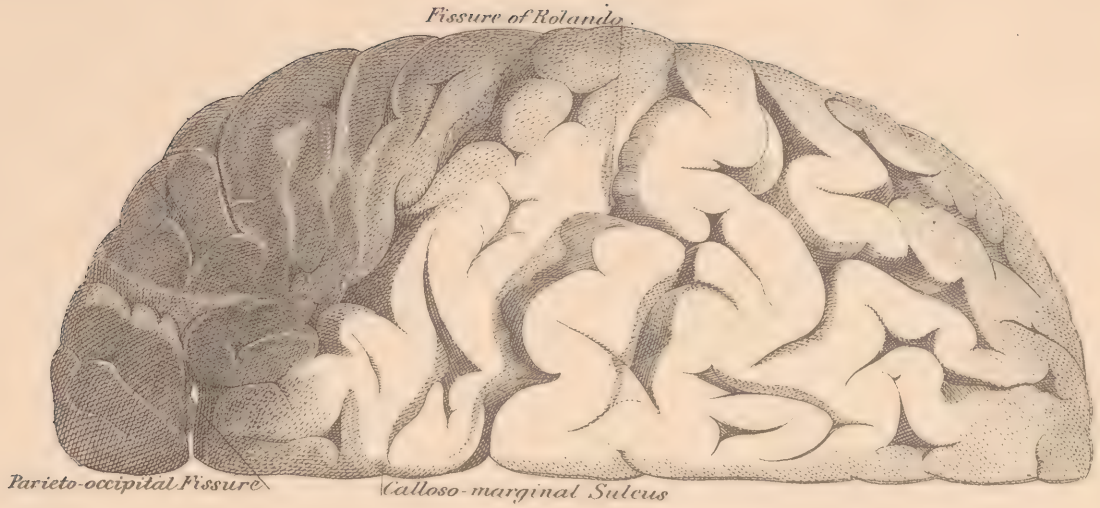


Fig 1

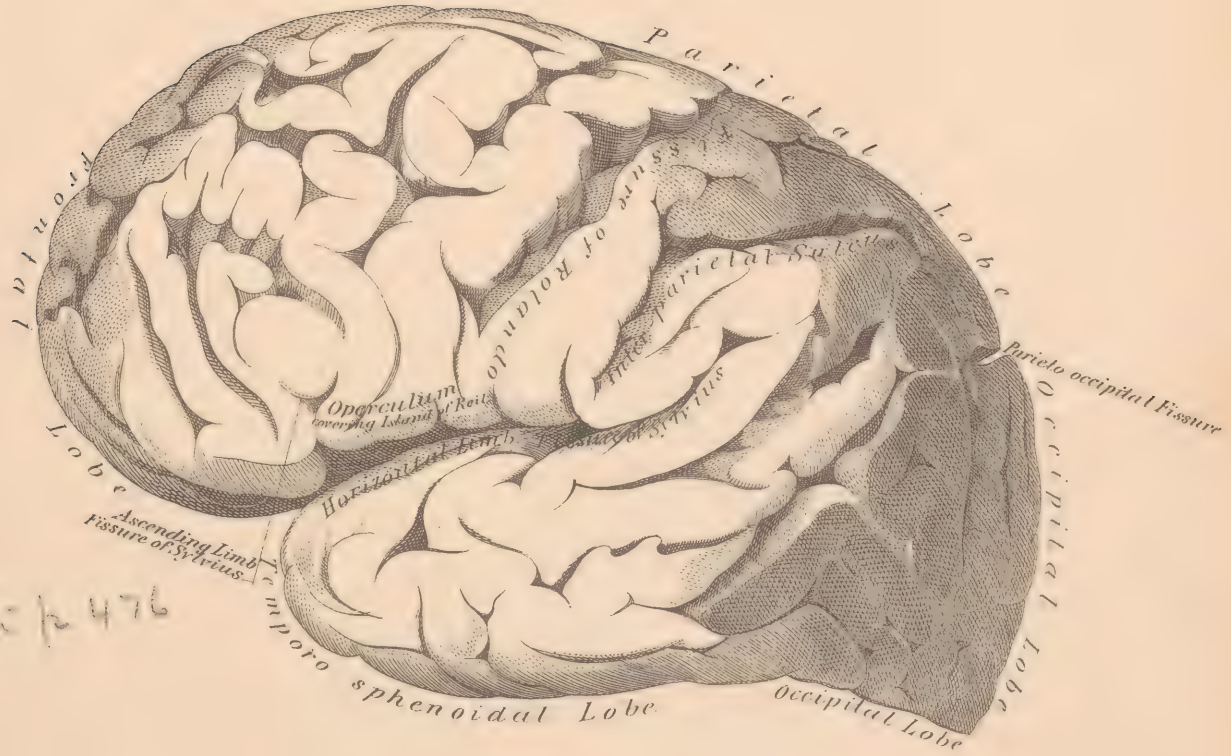


Fig 2

T. Sinclair & Son, Lith.

(1) *The Fissure of Sylvius.*—The fissure of Sylvius is the most important fissure of the cerebrum. It arises from the base of the brain behind the anterior perforated space at the outer side of the optic chiasm. It passes thence outward to gain the lateral aspect of the hemisphere, along which it passes obliquely upward and backward, separating the frontal from the temporo-sphenoidal lobe. It soon divides into two branches, of which the anterior branch (the shorter, or ascending) passes upward and forward a short distance, while the other (the longer, or horizontal) passes in the line of the original depression upward and backward toward the posterior portion of the parietal lobe. This fissure appears about the fourth month of fœtal life.

The *operculum* constitutes the posterior third of the inferior frontal convolution. It is received in the interval between the limbs of the fissure of Sylvius.

The terms "supra-marginal" and "infra-marginal" are often used by writers on clinical medicine. They relate to the horizontal limb of the fissure of Sylvius on the lateral surface of the cerebrum. The term "supra-marginal" is applied to the convolutions about the ends of the intra-parietal fissure and of the fissure of Rolando; the term "infra-marginal" is more exactly equivalent to the first temporal convolution.

(2) *The Fissure of Rolando* (central fissure).—This fissure, which is for the greater part best seen on the lateral aspect of the hemisphere, begins at the median (inner) border of the hemisphere, where it may appear upon the median surface as a fissure directed obliquely upward and forward. Upon the lateral (outer) aspect of the hemisphere it extends downward and forward to terminate near the horizontal branch of the fissure of Sylvius. The convolution in front of the fissure has received the name of the *anterior central* (pre-central or ascending frontal), and that behind the fissure the name of the *posterior central* (ascending parietal) convolution. Both of these convolutions are often spoken of as *central.*

This fissure appears about the sixth month. According to W. Krause, it is determined by a vein which in the fœtus extends from the superior longitudinal sinus to the middle cerebral vein.

(3) *The Parieto-Occipital Fissure.*—This fissure is best seen on the median surface of the hemisphere. It separates the parietal from the occipital lobe. It begins upon the median surface of the hemisphere at the calcarine fissure and extends thence upward and outward, presenting a slightly convex border anteriorly, and serving to separate the cuneate from the quadrate lobule (see p. 480). It commonly appears upon the outer surface of the cerebrum as a small transverse sulcus about midway between the apex of the occipital lobe and the posterior free border of the corpus callosum. It is bounded in front by the first occipital convolution. This fissure is apt to be distorted by careless handling when the brain is out of position.

(4) *The Calcarine Fissure* is confined to the median aspect of the hemisphere. It begins at the posterior part of the occipital lobe by the union of two small oblique sulci. The fissure joins the lower extremity of the parieto-occipital fissure, and is continued upon the temporo-sphenoidal lobe. It separates the gyrus fornicatus from the superior occipito-temporal or uncinate convolution, and answers in position to the eminence on the floor of the posterior horn of the lateral ventricle termed the hippocampus minor (calcar avis).

(5) *The Hippocampal Fissure* (dentate fissure), like the preceding, is confined to the median aspect. It lies between the dentate and hippocampal convolutions, and answers in position to the eminence on the floor of the descending horn of the lateral ventricle called the hippocampus major.

(6) *The Olfactory Fissure* lies on the basal aspect. It runs parallel to the median border of the frontal lobe between the first and second olfactory convolutions. It lodges the olfactory bulb.

(7) *The Collateral Fissure*, so named from the fact that it often answers to the position of a rounded eminence in the descending horn of the lateral ventricle which is called *the collateral eminence*, is best seen on the basal aspect of the occipital and temporo-sphenoidal lobes, and ends at a point about opposite to the hippocampal convolution near the uncinate process.

THE CEREBRAL LOBES.—The arrangement of the lobes of the cerebrum and their attendant topographical features is as follows:—

(1) The Frontal Lobe, inclusive of
  The operculum.
  The olfactory convolutions.
(2) The Parietal Lobe, inclusive of
  The superior parietal lobule or convolution.
  The quadrate lobule.
  The inferior parietal lobule or convolution.
(3) The Occipital Lobe, inclusive of
  The cuneate lobule.

(4) The Temporo-Sphenoidal Lobe, inclusive of
The lingual lobule (internal temporo-occipital convolution).
The fusiform lobule (external temporo-occipital convolution).

(5) The Central Lobe, or the Island of Reil.

The bands of gray matter which pass round the ends (whether initial or terminal) of the cerebral fissures often receive distinct names. This is demanded by the fact that they often lie in regions between the end of one convolution and the beginning of another, and yet cannot with propriety be included in either. From the fact that they lie in regions of great functional, and therefore of clinical value, special attention should be given to them by the student. Such are the para-central convolutions, the angular gyrus, and the annectant convolutions. The terms "bridging convolutions," and "connecting gyri," are often used in describing such bands.

THE LATERAL AND BASAL ASPECTS OF THE CEREBRAL HEMISPHERE.

(1) *The Frontal Lobe.*[1]—On the lateral aspect the frontal lobe is bounded behind by the fissure of Rolando and the imaginary line extending thence to the fissure of Sylvius. In rare instances, as represented in fig. 2, Plate LXXI., the fissure of Rolando extends to the fissure of Sylvius. The lobe is bounded below by the fissure of Sylvius forward from the point of junction with it of the produced line of the fissure of Rolando. On the basal (orbital) aspect the lobe is bounded posteriorly by the anterior perforated space.

The lateral surface of the lobe is irregularly triangular, and answers pretty accurately to the temporo-frontal region of the skull. It commonly possesses three fissures, named the *superior frontal*, the *inferior frontal*, and the *præ-central* fissure.—The convolutions are four in number, the *superior frontal*, the *middle frontal*, the *inferior frontal*, and the *anterior central*. (See p. 477.)

The basal (orbital) aspect of the frontal lobe is slightly concave, and rests upon the floor of the anterior cerebral fossa. It is marked by the *olfactory fissure* for the olfactory bulb and pedicle, and by an *orbital fissure*, which is tri-radiate in form and lies to the outer side of the olfactory fissure.—The convolutions on either side of the olfactory fissure are called the *olfactory convolutions*, and are continuous on the median aspect of the cerebral hemisphere with the great marginal convolution. The convolution to the outer side of the orbital fissure is part of the *inferior frontal convolution*. The convolution to the median side of the olfactory fissure is the *straight gyrus* or *convolution*. No boundary to the frontal lobe exists in the median aspect.[1]

[1] The fronto-parietal area is a term in use by some writers to include both the frontal and parietal lobes. Within the "frontal lobe" Bouillaud includes the anterior half (nearly) of the cerebral hemisphere.

[1] Under the name *pre-frontal lobe* physiologists and clinical writers include that portion of the frontal lobe in advance of the anterior central convolution. It may be said in a general way to represent the anterior half of the true frontal lobe, being that portion of the latter which rests within the anterior cerebral fossa, and contains the olfactory and lower portions of the frontal convolutions. The term is an unfortunate one; for whatever its clinical significance, it implies that the region is in advance of the frontal lobe when it is in truth embraced within it.

EXPLANATION OF PLATE LXXX.

Fig. 1. View of the structures displayed upon the right side of a median sagittal (longitudinal) section of the brain —semi-diagrammatic. A variation is seen in the failure of the calloso-marginal fissure (sulcus) to reach the dorsal aspect of the hemisphere. The usual disposition is seen in fig. 1, Plate LXXXI. In the absence of this branch of the fissure, the parietal lobe is without anterior limitation. The words "parietal lobe" should not lie further forward than the dotted line representing the usual termination of the calloso-marginal fissure. For "transverse fissures," read "transverse fissure;" for "calcarine fissures," read "calcarine fissure;" for "pituatary body," read "pituitary body." The anterior boundary of the anterior commissure has been omitted. Appended is an outline figure of the corrections.

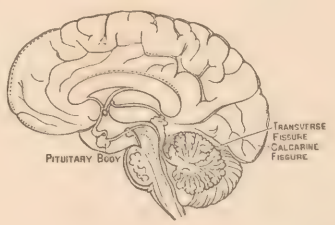


Fig. 2. The base of the brain, together with the upper portion of the spinal cord. For "Mamillary Body," read "Mammillary Bodies."

PLATE LXXX

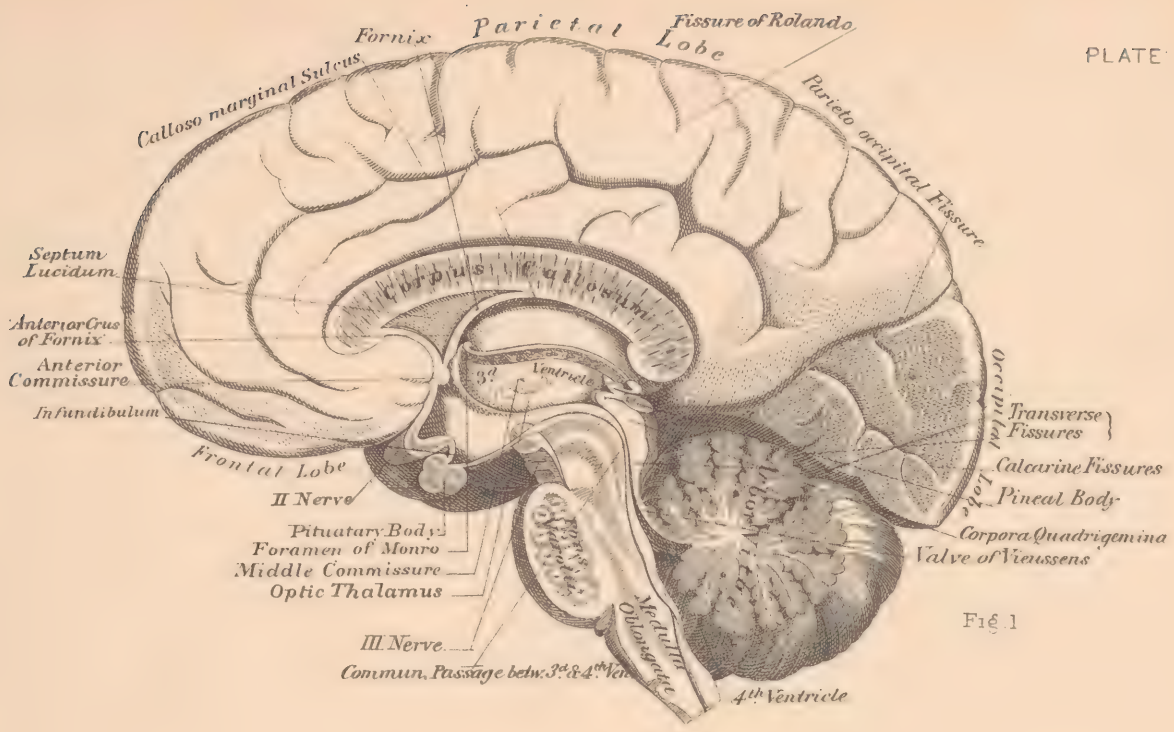


Fig 1

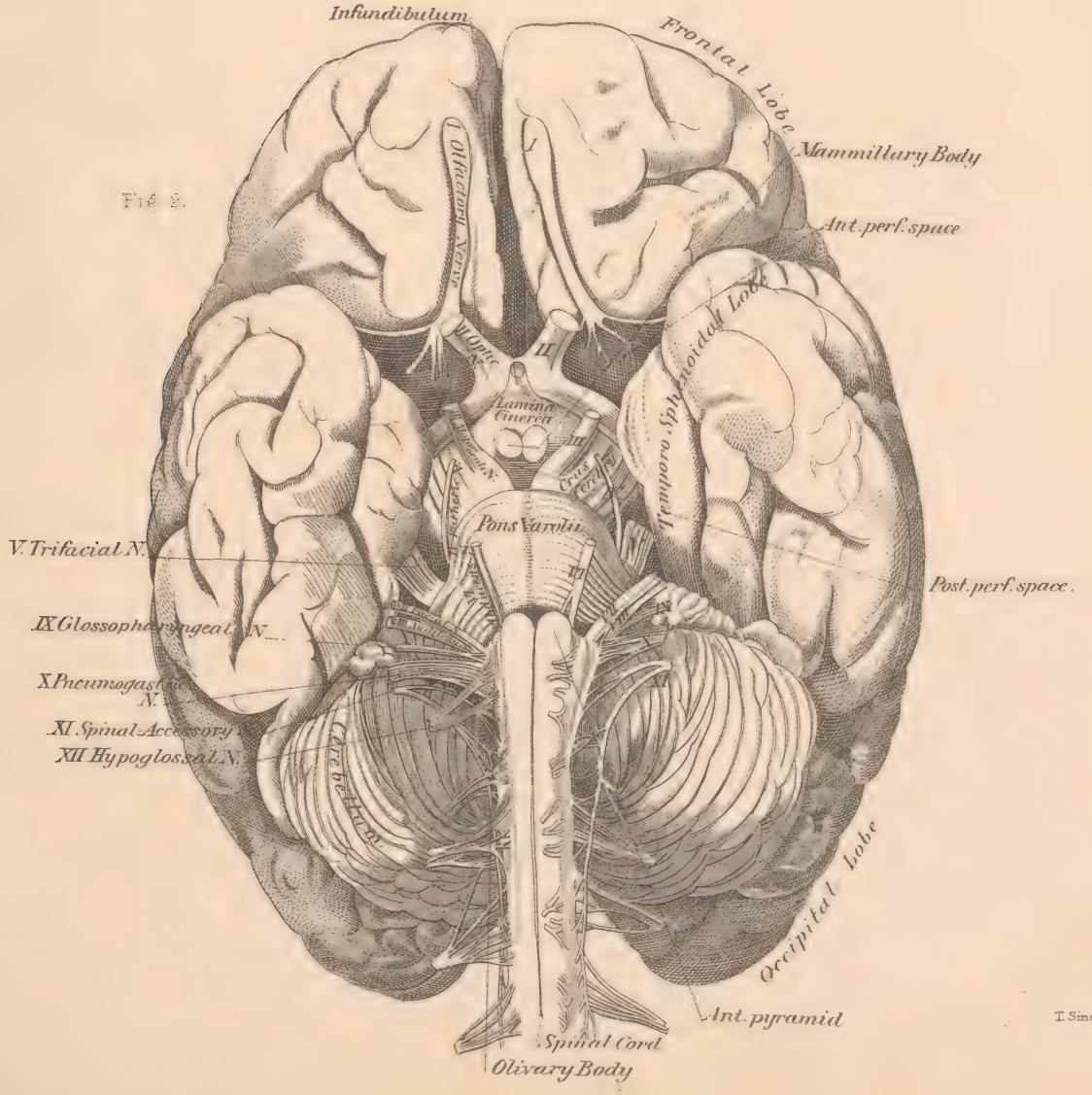


Fig 2.

T. Sinclair & Son, Lith.

(2) *The Parietal Lobe.*[1]—The parietal lobe is defined in front by the fissure of Rolando; behind by the continuation of the line of the parieto-occipital fissure; below by that portion of the posterior limb of the fissure of Sylvius which lies back of the line of the fissure of Rolando. The parietal lobe lies within the concavity of the skull defined by the parietal bone and the ascending portion of the occipital bone.

The main fissure of the parietal lobe is the *intra-parietal* (fig. 2, Plate LXXI.), which extends obliquely along the lateral aspect of the lobe, more or less parallel with the fissure of Rolando. The fissure begins about the posterior limb of the fissure of Sylvius, and passes upward and backward beyond the parieto-occipital fissure. It occasionally terminates in the transverse occipital fissure. The intra-parietal fissure aids in defining the *posterior central convolution* (see p. 477), the *superior parietal lobule*, the *inferior parietal lobule*, and the *first occipital convolution*. Infrequently it joins the fissure of Sylvius.

The superior parietal lobule. — This lobule lies between the posterior central convolution and the parieto-occipital fissure. Inferiorly it is bounded by the intra-parietal fissure, and superiorly by the longitudinal fissure. The *first annectant convolution* is a name given to the convolution uniting the superior parietal lobule with the occipital lobe.

The inferior parietal lobule.—This lobule lies below the intra-parietal fissure, and consists in part of simple and in part of complicated convolutions. In front lies the posterior central convolution, and below the hinder end of the horizontal limb of the fissure of Sylvius and the upper end of the temporal convolutions. The *supra-marginal gyrus* or *convolution* is the name given to the convolution embracing the terminal portion of the horizontal limb of the fissure of Sylvius.—The *angular convolution* winds round the posterior end of the first temporal fissure. It is composed of a portion of the inferior parietal lobule and the first temporal convolution. This convolution joins the occipital by two or three *annectant convolutions.*—Very rarely the fissure of Sylvius is prolonged into the intra-parietal fissure, thus separating the supra-marginal from the angular gyrus.

(3) *The Occipital Lobe.*—The occipital lobe is that portion of the cerebrum which lies behind the parieto-occipital fissure. The most distinct boundary lies on the median aspect, and the least distinct on the basal aspect, where it blends with the temporo-sphenoidal lobe. According to some writers, the upper angle of the petrous portion of the temporal bone determines a line of separation between the temporo sphenoidal and the occipital lobes. The basal aspect of the lobe rests upon the tentorium, and the lateral aspect is received in the concavity of the ascending portion of the occipital bone. The median surface of the occipital lobe aids in defining the longitudinal fissure.

The chief fissure (*transverse occipital*) lies on the upper part of the lateral aspect, and is joined at an angle by the intra-parietal fissure. It is often indistinct or absent.

Clinical writers use the term "end lobe" in describing the angular portion of the occipital lobe at the junction of the lateral, basal, and median surfaces.

In addition to the above the occipital lobe presents the first, second, and third occipital, the inferior occipito-temporal, and the descending convolutions.

(4) *The Temporo-Sphenoidal Lobe* (parieto-temporal) is situated behind and below the horizontal limb of the fissure of Sylvius. It is continuous behind with the occipital lobe, and is the only lobe which does not appear in part upon the great longitudinal fissure.

The temporo-sphenoidal lobe presents two aspects, a lateral and a basal, which pass into each other by rounded borders. As its name implies, the lobe lies within the middle cerebral fossa upon the portions of the temporal and sphenoid bones there found. Its lower extremity is on a level with the base of the orbit.

The lower extremity appears as a rounded, free projection from the cerebral mass, and yields a small median surface, which is, of course, distinct from the median surface of the hemisphere at the great longitudinal fissure. Such a surface may be defined with reasonable accuracy by a line extending parallel to the crura at the side of the central region of the base of the brain between the anterior perforated space and the pons Varolii.

The *superior temporal* (parallel) *fissure* is the most constant. It runs parallel with the posterior limb of the fissure of Sylvius, and forms the lower boundary of the first temporal convolution.

The *middle* and *inferior temporal fissures* extend nearly parallel with the above, the former upon the lateral, and the latter upon the inferior surface.

The *occipito-temporal fissure* extends upon the under surface of the occipito-temporal lobe. It lies between the superior and inferior occipito-temporal convolu-

[1] *Middle Lobe.*—The posterior part is called by Turner the postero-parietal, and the upper part by Ecker the upper parietal. In clinical reports the parietal lobe is occasionally referred to as all the cortex between the fissure of Rolando and the extreme tip of the occipital lobe.

tions. It often receives the name of the collateral fissure because of its constant relation to the *eminentia collateralis* of the descending horn of the lateral ventricle.

The convolutions lie between the fissures as determined, and may be named as follows:—

The *superior* (infra-marginal gyrus), the *median*, and the *inferior* temporal; the *occipito-temporal* (fusiform lobule), the *internal* (lingual lobule), and the *external*.

The term *subicular* region, *i. e.*, the region of the *subiculum cornu Ammonis* (sigmoid convolution of the cornu, including the *uncus*), is sometimes given to the tip of the temporo-sphenoidal lobe.

(5) The *Central Lobe* or *Island of Reil* is a clump of small sulci and convolutions situated at the bottom of the fissure of Sylvius, and overhung by the operculum. It measures about one and one-half inch in its longest diameter, by one inch in its shortest. The sulci radiate forward, upward, and backward, defining six convolutions, named the *gyri breves* (gyri operti).

The cortex of the island of Reil corresponds in position to the outer surface of the lenticular nucleus. Two layers of medullary matter inclose the *claustrum*, namely, the external capsule on the inner side, and a small inter-cortical layer on the outer. It is continuous in front with the cortex covering the anterior lacerated space, and the outer orbital convolution, and behind with the temporo-sphenoidal lobe.

THE MEDIAN (INNER) ASPECT OF THE CEREBRAL HEMISPHERE.

The median aspect of the cerebral hemisphere (fig. 1, Plate LXXX., fig. 1, Plate LXXXI.) is that portion of the external surface which lies in the plane of the great longitudinal fissure of the cerebrum. By means of the internal olfactory convolution, it is continuous with the basal aspect anteriorly, and by means of the occipito-temporal convolutions with the same aspect posteriorly.

The median aspect could be divided by arbitrarily selected lines into areas answering to the frontal, parietal, and occipital lobes, but custom has sanctioned a method of division which makes the topography of the median aspect independent of that of both lateral and basal aspects.

The median surface furnishes the cuneate, quadrate, and para-central lobules.

The Cuneate Lobule (wedge-shaped lobule) lies at the posterior part of the median aspect, and is bounded by the parieto-occipital fissure above, and by the calcarine fissure below.

The Quadrate Lobule (præcuneus) lies in front of the cuneate lobule (see p. 477). It lies between the parieto-occipital fissure and the ascending portion of the calloso-marginal sulcus. In front it is continuous with the gyrus fornicatus.

The Para-central Lobule is the region immediately about the median end of the fissure of Rolando (Betz), and is, of course, near the vertex and directly in front of the parieto-occipital fissure.

The fissures are the following: The calloso-marginal, the hippocampal, the calcarine, the parieto-occipital, and the occipito-temporal.

The Calloso-Marginal fissure begins beneath the genu of the corpus callosum, and extends upward and backward to reach the vertex at a point a little posterior to the fissure of Rolando. It aids in defining the quadrate lobule. According to Turner, a fissure is prolonged backward from it through the quadrate lobule toward the parieto-occipital fissure.

EXPLANATION OF PLATE LXXXI.

Fig. 1. A sagittal (longitudinal vertical) section of the cerebrum, a little to the left of the median line. The words "Gyrus fornicatus" have been placed above the calloso-marginal sulcus, when they should have been placed below it. For "Median Occipital Temp. Con.," read "Median Occipito-Temp. Con." The corrections are made graphically in the outline herewith appended.

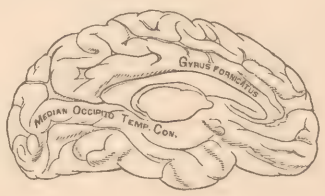


Fig. 2. The lateral aspect of the external surface of the left cerebral hemisphere.

Fig. 3. The dorsal aspect of the external surface of the cerebrum.

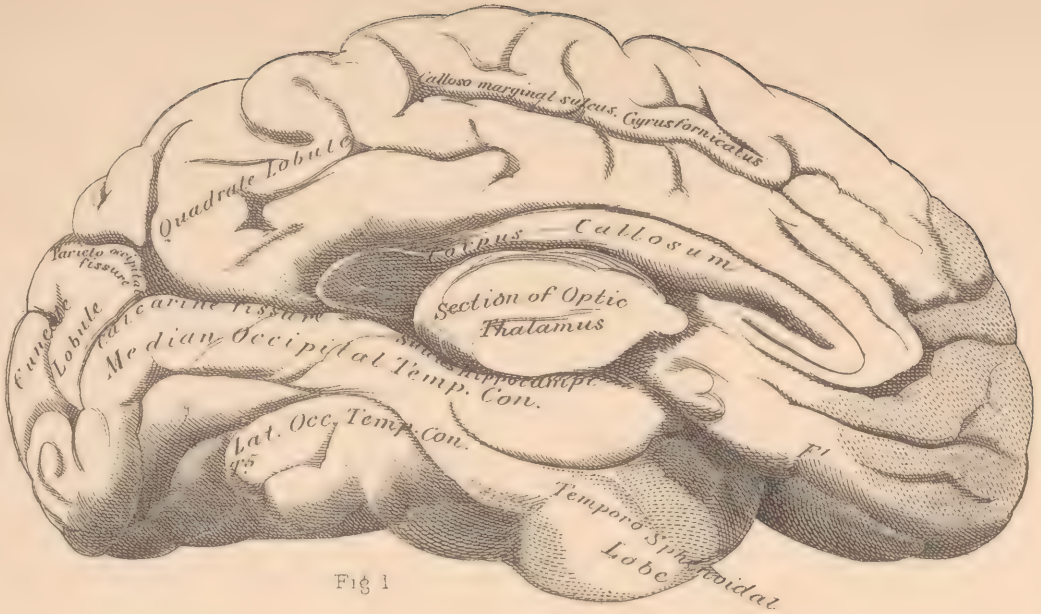


Fig 1

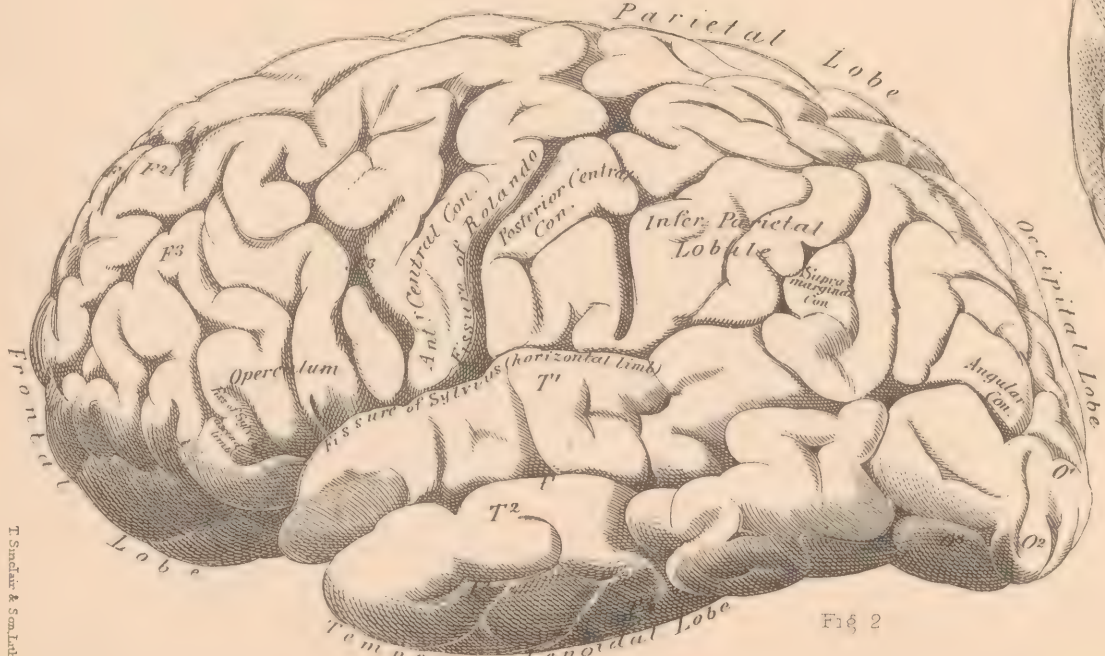


Fig 2

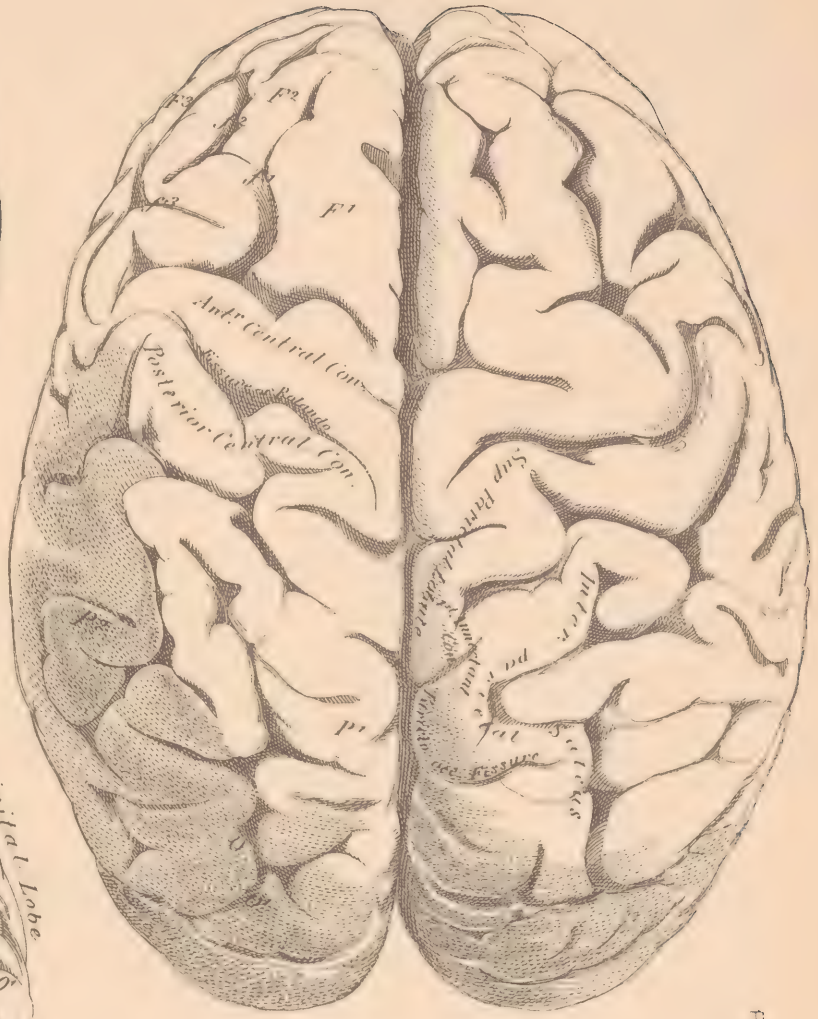


Fig 3

PLATE LXXXI

T. Sinclair & Son Lith.

The Hippocampal, the Calcarine, and the Parieto-Occipital Fissures have been described under the head of the main fissures (see p. 477).

The convolutions of the median aspect are the gyrus fornicatus, and the hippocampal and dentate convolutions.

The Gyrus Fornicatus (marginal convolution) begins as a small eminence beneath the anterior flexure of the corpus callosum, at which point it is connected with the hinder end of the median olfactory convolution (gyrus rectus) near the anterior perforated space. It follows the curve of the corpus callosum, and at a point opposite its free posterior border narrows to pass into the temporo-sphenoidal lobe, where it terminates in the hippocampal convolution. Sometimes a small gyrus joins this convolution to the apex of the cuneate lobe. According to Meynert, the temporal extremity of the fibres of the convolution can be traced to the straight olfactory sulcus.

The Hippocampal Convolution (superior occipito-temporal convolution, uncinate convolution) results from the union of the gyrus fornicatus and the internal occipito-temporal convolutions. It embraces the lateral aspect of the crus cerebri, and runs to the tip of the temporo-sphenoidal convolution, where it ends in a small hook-like convolution, named the *uncus*, which lies at the beginning of the fissure of Sylvius, behind the anterior perforated space.

The Dentate Convolution (fascia dentata) begins behind the posterior free border of the corpus callosum, to the inner side of the terminal portion of the gyrus fornicatus, and ends upon the uncus. It thus describes a curve nearly concentric with that of the hippocampal gyrus and of the hippocampal fissure. The lower portion lies upon the cortex, where it is continuous with the lateral ventricle directly in front of the fimbriated body of the fornix. It is well displayed upon exposure of the descending horn of the lateral ventricle from within, and is in this relation commonly described as a part of the internal structure of the cerebrum. (See Fig. 95.)

II. THE STRUCTURES EMBRACED WITHIN THE CEREBRUM.

When the cerebrum is divided, as with the knife, the external portion is seen to be composed of a relatively thin layer of gray matter called the cortex, which covers and surrounds the white matter, dipping down into the sulci and fissures which separate the different convolutions and lobes of the brain. At and near the base of the cerebrum, aggregations of gray matter are again seen, separated in definite order by masses of the white.

The following list of titles will serve as a basis upon which the arrangement of the structures entering into the cerebrum may be discussed:—

The Lateral and Third Ventricles.
The Septum Lucidum.
The Fifth Ventricle.

- The Corpus Striatum
  - Gray matter
    - The Caudate Nucleus.
    - The Lenticular Nucleus.
  - White matter
    - The Internal Capsule.
    - The External Capsule.

The Optic Thalamus.
The Cerebral Commissures.

Fig. 94.



A horizontal section of the cerebrum at the level of the pineal body. *p o t*, pulvinar of the optic thalamus; *p c l v*, posterior cornu of the lateral ventricle; *p b*, pineal body; *c c*, posterior flexure (splenium) of the corpus callosum; *a f c c*, anterior flexure of the corpus callosum.

THE LATERAL AND THIRD VENTRICLES.

THE LATERAL VENTRICLES.—The Lateral Ventricles are two large cavities within the cerebrum, one for each of the hemispheres. They are continuous toward the base of the brain with the third ventricle, and with each other by a small opening directly behind the anterior pillars of the fornix, called the foramen of Monro.[1] Through the third ventricle, by

[1] In the dissection of the base of the brain, when the gray matter in the floor of the third ventricle has been removed so as to expose

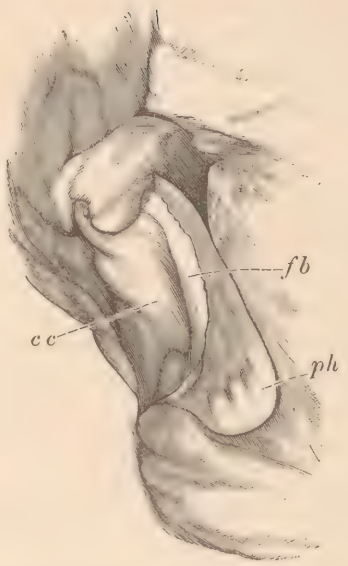
means of the *iter a tertio ad quartum ventriculum*, they communicate with the fourth ventricle. Each lateral ventricle is lined by a delicate layer called the *ependyma*, which in the embryo is covered with cilia. The cilia disappear for the most part in the adult.

Each lateral ventricle is bounded above by the corpus callosum, and below by the upper surface of the corpus striatum and the upper surface of the optic thalamus with the associated *tænia semicircularis*. The thalamus is in part concealed by the fornix, which appears to separate the floor of the lateral ventricle from the third ventricle. The lateral ventricles are separated from one another by the septum lucidum, but are united, as above mentioned, by the foramen of Monro.

The central cavity of each ventricle is so extended as to form three diverticuli or horns, the anterior, middle, and posterior.

The *anterior horn* is the smallest of the three, and is formed by the front of the ventricle narrowing sharply as it follows the curve of the anterior extremity of the corpus striatum.—The *middle horn* (descending horn, lower horn) winds round the optic thalamus to enter the temporo-sphenoidal lobe, along which it passes to its extremity. Its floor is occupied by a rounded eminence, *the hippocampal eminence*, or hippocampus major, which terminates at the lower extremity of the horn, to expand into two or three digitate processes, the *pes hippocampi*. The medullary matter is thin over the hippocampal eminence, the bulk of which is due to the cortex as it constitutes the boundaries of the hippocampal sulcus. The *fimbriated body* lies in advance of the hippocampus and of the dentate convolution in front of the last-mentioned structure. (See Fig. 95.) The descending horn accommodates a fold of the choroid plexus.—The *posterior horn* is a small but distinct structure extending into the occipital lobe. At its median side is found an elliptical elevation called the *lesser hippocampal eminence* (hippocampus minor, calcar avis, ergot). At the junction of the posterior with the descending horn a second swelling is seen, known as the *eminentia collateralis* (pes accessorius).

Fig. 95.



A diagrammatic view of the pes hippocampi (*p h*), the fimbriated body (*f b*), and the cortex of the cerebrum (dentate body) (*c c*), arranged in order from right to left. The remaining structures of the figure are portions of the cerebrum which have been imperfectly reproduced.

The relations between these eminences and the calcarine and collateral fissures have been already described, p. 477.

THE THIRD VENTRICLE.—The Third Ventricle is a narrow chink between the vertical opposed sides of the optic thalami. It is bounded above by the body of the fornix, and below by two converging oblique lines which assist in forming the lamina cinerea and infundibulum. In front is the posterior free border of the septum lucidum, as defined by the anterior

the ventricle, the two openings, one on either side, are plainly visible behind the pillars of the fornix. In cases of chronic excess of serum in the ventricles, the foramen is large enough to admit the point of the finger.

EXPLANATION OF PLATE LXXXII.

Fig. 1. A frontal section of the brain through the body of the fornix. The middle commissure should have been shaded, and the vertical line in the body of the fornix omitted. For "Pituatary Body," read "Pituitary Body."

Fig. 2. The cerebellum, seen from above.

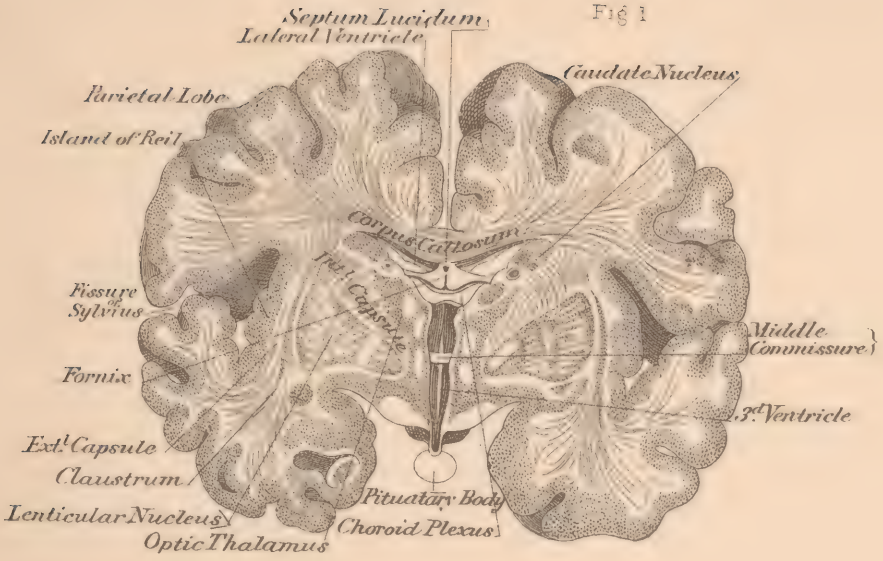
Fig. 3. A diagrammatic representation of the spinal cord and its membranes.

Fig. 4. A diagrammatic view of the anterior portion of the stem of the brain, and the optic tracts and related parts.

Fig. 5. The cerebellum, seen from beneath.

Fig. 6. The cerebellum, corpora quadrigemina, pineal body, and optic thalami, seen from above. The superior vermiform process has been removed to display the valve of the fourth ventricle. For "Corpora Quadrigemia," read "Corpora Quadrigemina."

Fig 1



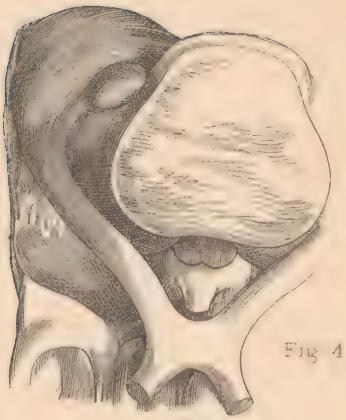


Fig 4.

Fig 2

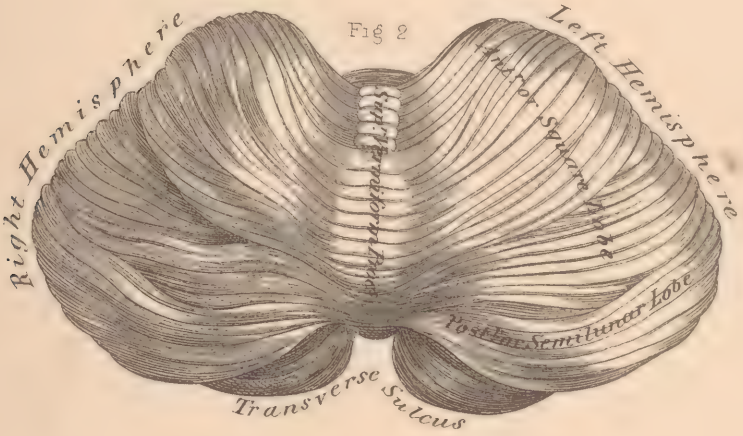


Fig 5.

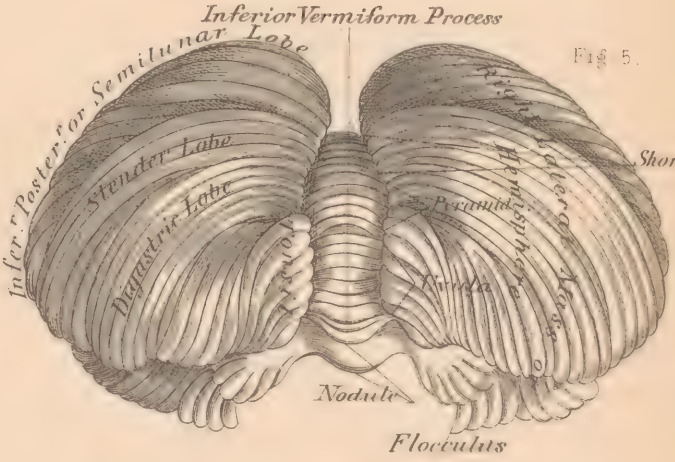


Fig 3

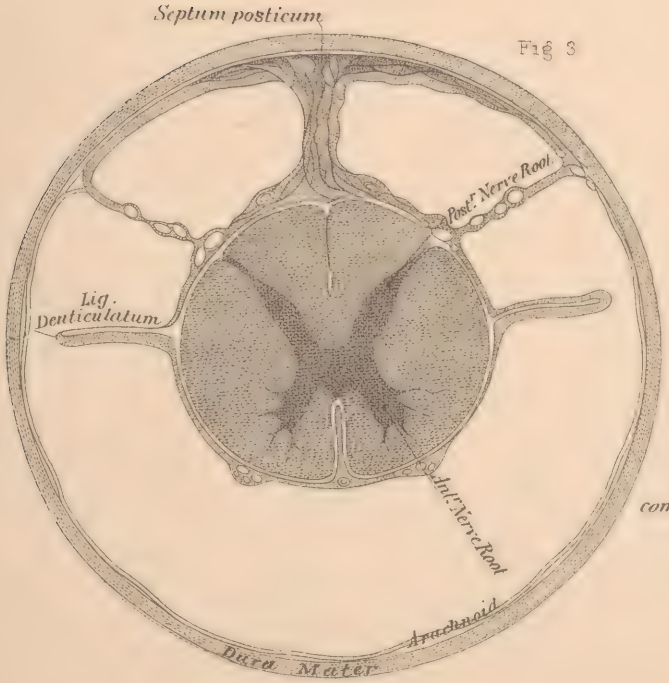
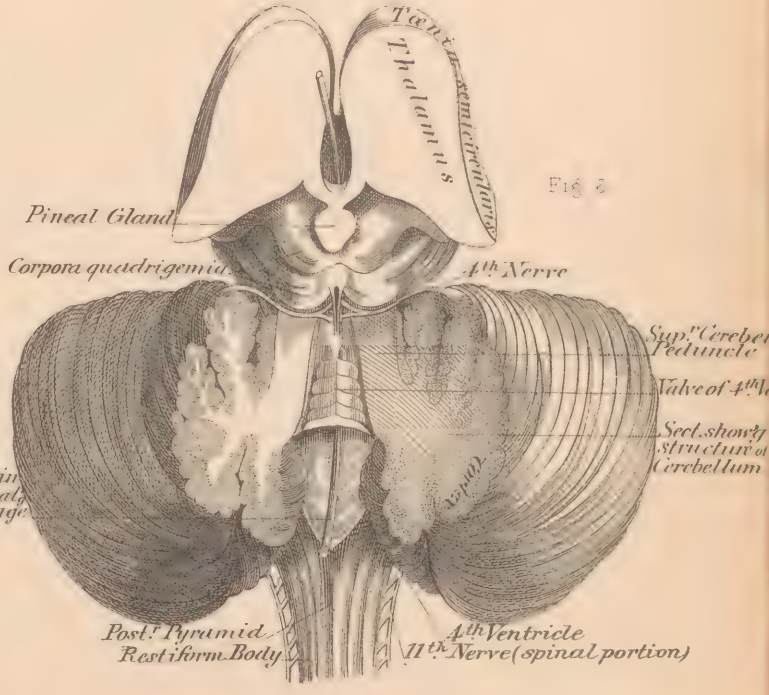
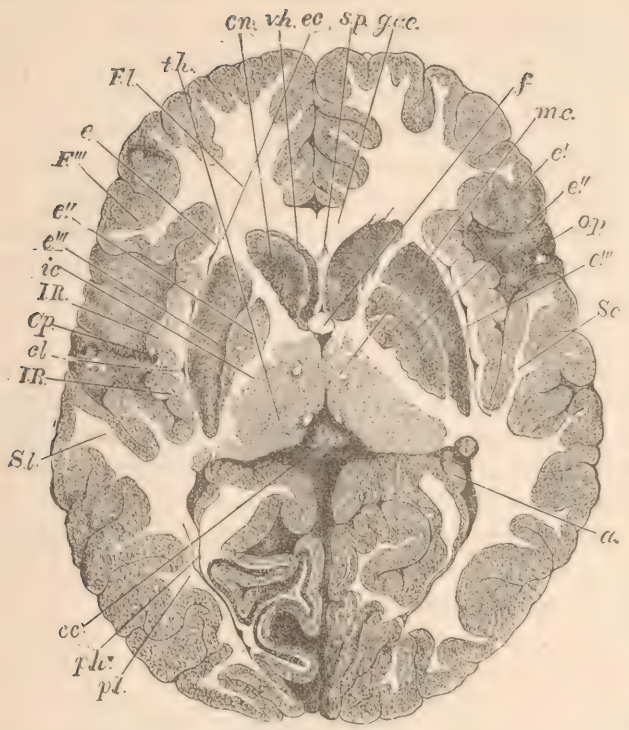


Fig 6



T. Sinclair & Son, Lith.

Fig. 96.



A horizontal section of the brain of an adult, made at the level of the posterior horn of the lateral ventricle. *e c*, external capsule; *v h*, anterior horn of the lateral ventricle; *c n*, striated body (caudate nucleus); *t h*, optic thalamus; *Fl*, frontal lobe; *e*, claustrum; *F'''*, third frontal convolution; *e''*, first segment of the lenticular nucleus; *e'''*, outer segment of same; *I R*, island of Reil; *Cp*, operculum: *cl*, claustrum; *S l*, spheno-temporal lobe; *c c*, corpus callosum; *p h*, posterior horn of the lateral ventricle, *p l*; *a*, section of the hippocampal eminence, *Sc*; *m c*, middle commissure (the leader should be continued to a point midway between the thalami); *f*, fornix; *g c c*, genu of corpus callosum; *s p*, septum lucidum.

curve of the fornix, below is the *lamina cinerea*, while behind lies the posterior commissure. It is here in relation with the corpora quadrigemina and the pineal body.

The third ventricle is crossed by two commissures, the anterior and the posterior. The *anterior commissure* is seen in the space between the anterior legs of the fornix. The *posterior commissure* joins the two thalami (see page 487). The so-called *middle commissure* is soft and cineritious, and unites the opposed surfaces of the thalami.

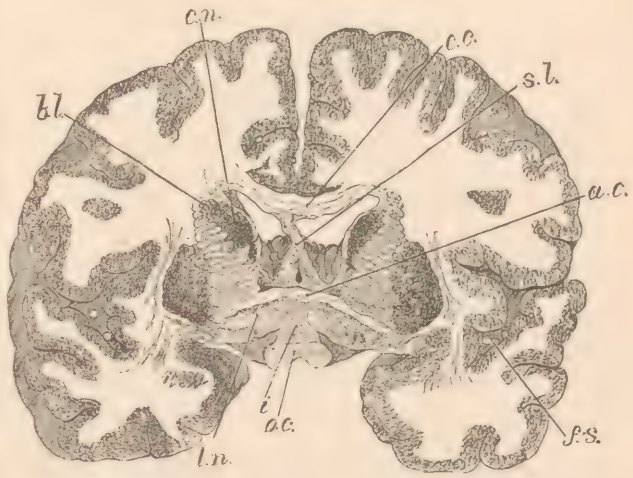
THE SEPTUM LUCIDUM.

The anterior pillars of the fornix are continuous in front with a septum, the *septum lucidum*, which extends to the corpus callosum, filling in the space within the curve of the anterior flexure of the corpus callosum and the rostrum, and at the same time serving to separate the anterior portions of the lateral ventricles from one another. As it passes toward the base of the brain, the septum lucidum ends at the point of nearest approach of the rostrum of the corpus callosum to the fornix at the anterior commissure. The septum is composed of two delicate laminæ, inclosing a small space called the fifth ventricle, which in some instances (rare except in the fœtus) communicates with the foramen of Monro by a minute opening between the anterior pillars of the fornix.

THE CORPUS STRIATUM.

The Corpus Striatum (striated body, anterior basal ganglion) is a name given to a large collection of gray and associated white matter lying upon the floor of the lateral ventricle, to the outer side and slightly in advance of the optic thalamus. The undissected corpus striatum presents the appearance of a smooth ash-colored pear-shaped mass, whose base being directed forward forms the under and outer boundaries of the anterior horn of the lateral ventricle, and whose tapering apex passes backward to the descending horn of the lateral ventricle, within which it is lost. Lying superficially between the corpus striatum and the optic thalamus is a thin ribbon-shaped mass of nerve-fibres which has received the name of the *tænia semicircularis*.

Fig. 97.



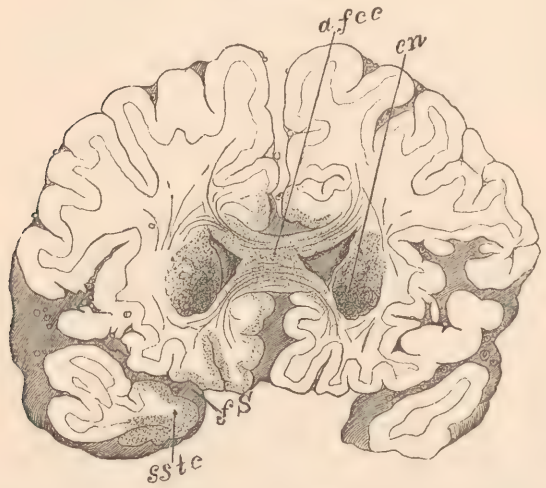
A frontal (transverse) section of the brain of an adult through the plane of the anterior perforated space. *c n*, caudate nucleus; *b l*, transverse section of bloodvessels; *l n*, lenticular nucleus; *i*, infundibulum; *o c*, optic chiasm; *f S*, fissure of Sylvius; *a c*, anterior commissure; *s l*, septum lucidum.

When the brain is bisected frontally (*i. e.*, from side to side vertically), at the plane of the optic chiasm (see Fig. 97), the corpus striatum is seen to be in great part imbedded in the basal portion of the cerebrum. Its lateral aspect is in intimate relation with the island of Reil, and its basal aspect with the anterior perforated space. The portion of the corpus striatum projecting within the lateral ventricle is its

least important part, for lying to its outer side and separated from it by a layer of nerve-fibres is a larger mass of gray matter. The corpus striatum, indeed, is a complex association of gray and white matter lying between the lateral ventricle, the region of the island of Reil, and the anterior perforated space, and is composed of the caudate nucleus, the lenticular nucleus, the internal capsule, and the external capsule.[1]

That portion of gray matter appearing in the lateral ventricle is called the *caudate nucleus* or *intraventricular ganglion.* As already seen, it is of pyramidal figure with its base forward and apex backward, lying nearly on the same plane as the optic thalamus, and, together with that structure, forming a portion of the floor of the lateral ventricle. The posterior portion of the caudate nucleus with the tænia semicircularis can be traced as the *circingle* to the region of the basal limit of the corpus callosum. (See Development.)

Fig. 98.



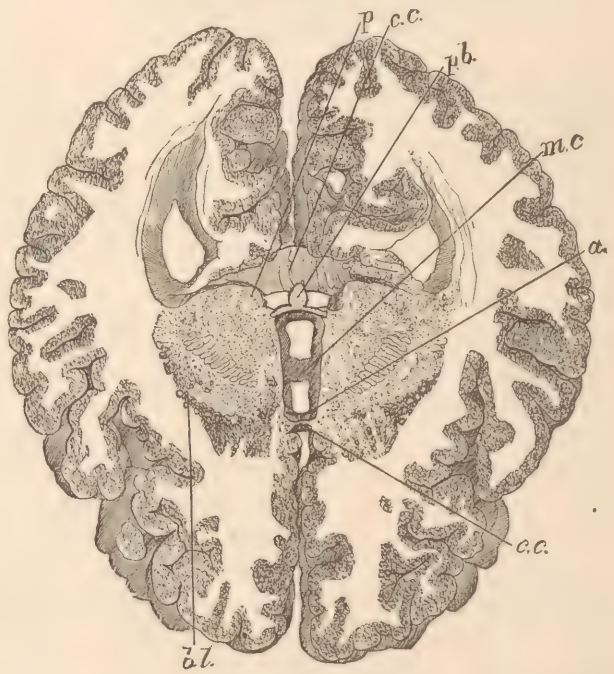
A frontal (transverse) section of the cerebrum at the curve of the anterior flexure of the corpus callosum. *a f c c*, anterior flexure of the corpus callosum; *c n*, caudate nucleus; *f S*, fissure of Sylvius; *s s t c*, section of temporo-sphenoidal lobe.

The *lenticular nucleus*, or *extraventricular ganglion*, is so named on account of its lateral (outer) surface being rounded and thus resembling a lentil in appearance. In frontal (transverse) sections it is much wider than the caudate nucleus, and is more complicated in character. The anterior portion is of a rounded form, and presents a uniform gray color. It lies opposite the island of Reil. The posterior portion is of the form of a triangle whose base is directed outward. The lenticular nucleus is divided by white septa into three segments, named, from within outward, the first, second, and third segments. In sagittal (longitudinal) section the posterior portion of the lenticular nucleus is seen to be of a brownish-red color, and thus resembles the thalamus, while the anterior portion is of an ash color.

The *internal capsule* is a large tract of white matter belonging to the pyramidal tract (see Minute Anatomy), and lying between the caudate nucleus and the optic thalamus on the inner side and the lenticular nucleus on the outer.

The *external capsule* is a small tract of white matter lying between the outer aspect of the lenticular nucleus and the cerebral cortex.

Fig. 99.



A horizontal section of the brain a little above the level of the pineal body. *p*, pulvinar of the optic thalamus; *c c*, corpus callosum; *p b*, pineal body; *m c*, so-called middle commissure; *a*, anterior commissure; *b l*, transverse section of bloodvessels.

THE OPTIC THALAMUS.

The Optic Thalamus[1] (posterior basal ganglion) is an irregularly oval mass composed for the most part of gray matter, which lies above the plane of the termination of the crus cerebri of the correspond-

[1] Writers are not agreed as to the exact use of the term corpus striatum. Rosenthal treats of the lenticular nucleus as a distinct ganglion, and of the internal capsule and the caudate nucleus as composing the corpus striatum. In systematic writings the term corpus striatum is often restricted to the caudate nucleus. Duret proposes to limit the term lenticular nucleus to the posterior brownish-red portion of the lenticular nucleus as above defined, and reserves the term "gray nucleus" to the anterior portion.

[1] From morphological data, the optic thalamus, pineal body, and pituitary body constitute the *thalamencephalon*.

ing side. After the removal of the structures above the lateral and third ventricles, the two thalami are seen lying behind and slightly to the median side of the corpora striata, where they form two slightly rounded masses, whose dorsal aspects assist in forming the floor of the lateral ventricle, and whose median aspects define the sides of the third ventricle. Above them to the median side lie the pineal body and the corpora quadrigemina — with both of which structures they establish connections.

The dorsal surface of the thalamus is uneven, and possesses an anterior tubercle and a posterior tubercle (pulvinar). The median aspect is marked a short distance from its base by a longitudinal groove (sulcus of Monro). At the junction of the dorsal and median aspects are seen the peduncles of the pineal gland. The thalami are united by the posterior commissure and, as already seen, by a band of gray matter, the so-called *middle commissure* (commissura mollis).

The lateral aspect of the optic thalamus is marked posteriorly by two small elliptical swellings called the *geniculate* bodies. The *external* (outer) *geniculate body* gives origin to the anterior root of the optic nerve, and the *internal* (inner) *geniculate body* gives origin to the inner root.

When seen in frontal (transverse vertical) section the lateral portion of the thalamus lies in contact with the internal capsule, the basal portions are in direct continuity with the gray matter of the crus cerebri, which here exist as the dispersed nerve-cells of the locus niger and other structures of the reticular and tegmental formations of the crus. (See Minute Anatomy.)

THE CEREBRAL COMMISSURES.

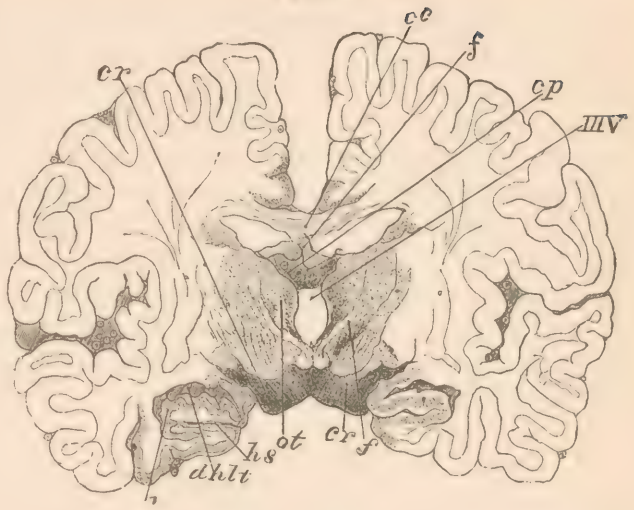
The Cerebral Commissures include—

The Corpus Callosum.
The Fornix.
The Anterior Commissure.
The Posterior Commissure.[1]

THE CORPUS CALLOSUM.

The Corpus Callosum (fig. 1, Plate XC., fig. 1, Plate LXXXI., fig. 1, Plate LXXXII.) is the main commissure of the cerebral hemispheres. It is a broad band about three inches in length and three-fourths of an inch in width, which is for the most part composed of transverse fibres. It is exposed at the base of the great longitudinal fissure, where its free dorsal surface is marked by a number of delicate transverse lines, a few longitudinal striæ (mesial fibres of the raphe) and lateral longitudinal striæ (tæniæ tectæ). Careful abduction of the cerebral hemispheres in front will expose the anterior end of the corpus callosum, which has received the name of the *anterior flexure* or *genu;* abduction of the hemispheres behind will expose the posterior end, which has received the name of the *posterior flexure* or *splenium*. The under surface of the splenium can also be seen for a short distance, as it overlies the pineal body and the corpora quadrigemina at the bottom of the transverse fissure. At the base of the brain two delicate bands called the *peduncles of the corpus callosum* overlie the anterior perforated spaces.

Fig. 100.



A frontal (transverse) section of the cerebrum at the plane of the corpora albicantia. *c c*, corpus callosum; *f*, fornix; *c p*, choroid plexus; *III V*, third ventricle; *f*, fornix; *c r*, crusta; *o t*, optic thalamus; *h s*, hippocampal sulcus or fissure; *d h l t*, descending horn of the lateral ventricle; *h*, position of pes hippocampi.

In a sagittal section of the brain in the median line (fig. 1, Plate LXXX., fig. 1, Plate LXXXI.) the corpus callosum is seen as a thin curved concealed band—*the rostrum*—which extends from the anterior flexure down to the base of the brain, where it is connected with the fornix and the lamina cinerea. The under surface lies at its anterior half in contact with the septum lucidum, and at its posterior half with the fornix. The rostrum, while apparently terminating upon the optic nerve, ends upon the lamina cinerea. —In a frontal section (fig. 1, Plate LXXXII., and Fig. 98, p. 484) of the brain through the anterior flexure, the fibres of the corpus callosum resemble the letter X; the fibres from the upper half extending above the upper border of the lenticular nucleus into the white cerebral matter of the frontal lobes, while those of the lower half are seen descending to enter the basal portion of the same lobes.

The corpus callosum is thinner at a point midway

[1] For an account of the so-called middle commissure, see p. 483.

between the flexures than at the flexures themselves, and is thicker at the posterior flexure than elsewhere.

In addition to the foregoing facts, it may be stated that the corpus callosum is connected by its transverse fibres with the central portions of the hemispheres, the *radii coronæ;* with the gyrus fornicatus by fibres passing thence from the anterior knee-like bend; with the occipital lobe by fibres radiating from the junction of the corpus callosum with the fornix (forceps major); and with the temporo-sphenoidal lobe by another set of fibres related to the preceding, which radiate and curve within the descending horn of the lateral ventricle.

THE FORNIX.

The Fornix (fig. 1, Plate LXXX., fig. 1, Plate LXXXI.) is a vault-like longitudinal commissure of nerve-fibres whose apparent origin is at the base of the brain, and whose arch overlies the third ventricle where it in part fuses with the posterior flexure of the corpus callosum. It is composed of the anterior crura, the posterior crura, and a body. It is customary to describe the fornix as a whole, as though it were not composed of right and left parts uniting in the median line of the brain.

The *anterior crura* (anterior pillars) arise in the anterior basal portion of the optic thalamus, descend and turn upward in the corpora mammillaria, and ascend as a pair of white cord-like structures, slightly separated along the posterior margin of the septum lucidum, in front (*i. e.*, forming the anterior margin) of the foramen of Monro and behind the anterior commissure, to join the body of the fornix from in front.

The *body* is a triangular figure whose base is directed backward. It lies on a horizontal plane beneath the corpus callosum, and forms in part the floor of each lateral ventricle. It also forms the roof of the third ventricle. The base in part fuses with the posterior flexure of the corpus callosum. The *psalterium* (lyra) is an arrangement of superficial oblique fibres which mark the under surface of the body.

The *posterior pillars* are continuous with the angles of the base of the body. They are flat ribbon-like bands which widen and diverge from their origin, each to enter the descending horn of the lateral ventricle of the same side, along the floor of which it passes. This band has received the name of the *corpus fimbriatum*, and terminates upon the *corpus dentatum.*

The fornix is thus seen to be a loop of fibres, composed of a right and a left half which fuse in a body. The anterior ends of the loop arise in the optic thalami near the median line of the base of the cerebrum; and the posterior ends lie near the tip of the temporo-sphenoidal lobe. The purpose of this association of the thalamus with the tip of the temporo-sphenoidal lobe by a route so circuitous is unknown.

THE ANTERIOR COMMISSURE.

The Anterior Commissure is a transverse band of nerve-fibres which unite the cerebral hemispheres at a point below the anterior flexure of the corpus callosum.

In a sagittal section of the cerebrum made by extending the plane of the longitudinal fissure to the base of the brain, the divided anterior commissure

Fig. 101.



A frontal (transverse) section of the cerebrum through the plane of the corpora quadrigemina and the posterior end (pulvinar) of the optic thalamus. The plane of the section is not exactly true, so that the right and left halves are not repetitions of each other; *v i*, velum interpositum; *opt th*, optic thalamus; *h s*, hippocampal sulcus; *c q*, corpora quadrigemina; *i t e r*, iter; *d h l v*, descending horn of the lateral ventricle; *p h*, pes hippocampi; *f*, fornix; *c c*, corpus callosum; *g l f*, great longitudinal fissure.

is seen as a narrow compressed band lying behind the rostrum of the corpus callosum as this structure passes to the base of the brain. Behind is the cavity of the third ventricle, and above is the septum lucidum.—In a horizontal section made so as to expose the third ventricle, the anterior commissure is seen passing across the cavity directly in front of the anterior pillars of the fornix. The fibres of the commissure can be traced in the substance of each hemisphere about the level of the exposed band, as far back as the temporo-sphenoidal lobe. This commissure appears to be compensatory with the corpus callosum. In animals in which the latter structure is rudimentary, the anterior commissure is of large size. Its description should be embraced in all accounts of specimens exhibiting defective development of the corpus callosum.

THE POSTERIOR COMMISSURE.

The Posterior Commissure is a small, transversely disposed, unimportant band, lying at the hinder end of the third ventricle beneath the peduncles of the pineal body. It unites the two thalami.

THE CORPORA QUADRIGEMINA.[1]

The Corpora Quadrigemina (optic lobes) are four transversely oval eminences which unite to form a single mass (quadrigeminal mass), situated above the iter, as it ends in the third ventricle. This mass lies within the superior transverse fissure of the brain between the optic thalami and the superior peduncles of the cerebellum. Above it is the pineal body and the posterior flexure of the corpus callosum. The dorsal surface is marked by a crucial depression. The smaller pair of oval eminences lying in front of the transverse portion of the depression constitute the *anterior tubercles* (nates, visual tubercles), and are united to the thalami and the crura cerebri by a slender prolongation on each side, which receives the name of the *anterior brachium*. The larger and more obliquely placed pair lying back of the transverse depression constitute the *posterior tubercles* (testes), and are united to the optic thalami and the crura cerebri on either side by a band which is somewhat larger than the corresponding part of the nates, and which receives the name of the *posterior brachium*.

Extending backward on each side from the corpora quadrigemina to the pons Varolii, though exposed but a short distance, is the *fillet*.

According to E. C. Spitzka,[1] the anterior pair only are homologous with the optic lobes of reptiles. The posterior pair, according to the same observer, belong to the hind brain. In structure the latter resemble the nuclei of sensory nerves.

THE PINEAL BODY.

The Pineal Body (pineal gland, conarium) is a small plummet-shaped mass of a reddish color which lies, with the apex directed backward, in the median line upon the anterior and upper portion of the corpora quadrigemina. From the angles of the base a pair of *peduncles* extends forward, each of which terminates upon the optic thalamus of its own side. A small ganglion is described lying beneath the peduncle.—Extending from the base of the pineal body downward to the floor of the third ventricle is a curved band of white substance, which, as seen from above, appears to extend from between the peduncles, and has hence received the name of the *posterior commissure* of the third ventricle.

The pineal body is composed of a number of cellular spaces inclosed in a matrix of gray matter. The spaces are lined with ciliated epithelium and contain particles of a sandy character, collectively termed *acervulus*, mixed with a glairy fluid. Some of the granules are rich in phosphates, while others contain an amyloid substance. The function of the pineal body is unknown.

THE BASE OF THE BRAIN.

The Base of the Brain is a region of topographical value, and includes that surface which answers pretty nearly to the base of the skull.

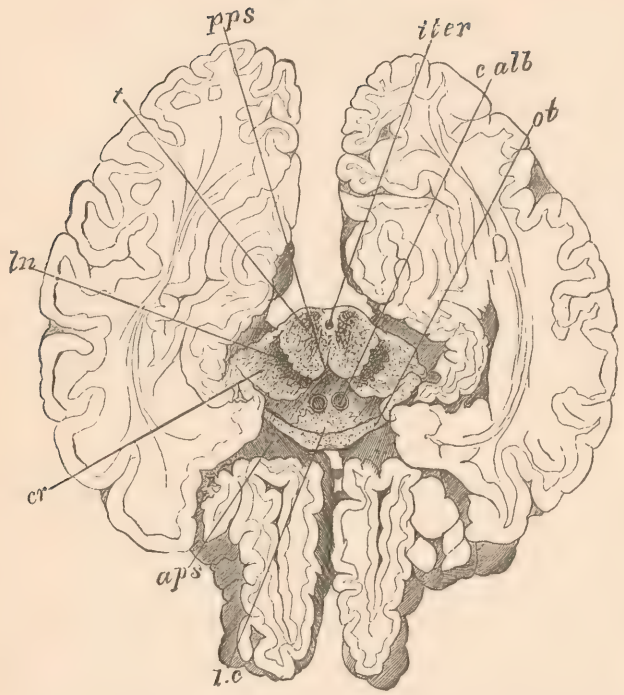
The base of the brain is divided into five portions, the medullary, cerebellar, pontal, crural, and cerebral.

The *medullary portion* answers to the anterior or inferior surface of the medulla oblongata. It lies upon the encranial aspect of the lower part of the basilar process of the occipital bone. At its sides are the apparent origins of the twelfth, eleventh,

[1] The corpora quadrigemina, the pineal body, the pituitary body, and the optic thalamus, make up a group of structures which may on morphological grounds be associated. For descriptions, however, designed for clinical purposes the retention of the association is not accompanied by sufficient advantage to balance the inconvenience of classifying median structures like the pineal body and the pituitary body with paired structures like the thalami, or the inaptness of separating the thalami from the striated body and the pyramidal tract. Hence it has been thought best to treat of the corpora quadrigemina and the pineal body as distinct structures, and to consider the optic thalamus with the cerebrum, and the pituitary body with the base of the brain.

[1] New York Med. Journ., 1881, xvii. 282.

Fig. 102.



A horizontal section of the cerebrum at the level of the base of the corpora albicantia. *Iter*, iter; *calb*, corpora albicantia, showing the white periphery and the interior gray matter; *ot*, optic tract; *lc*, lamina cinerea; *aps*, anterior perforated space; *cr*, crusta; *ln*, locus niger; *t*, tegmentum; *pps*, posterior perforated space.

tenth, ninth, eighth, and seventh nerves. In front, as it forms the pontal portion, are the apparent origins of the sixth nerves.

The *pontal portion* lies between the medullary and the crural. Its anterior border answers to the line of the posterior clinoid processes of the sphenoid bone. It is composed of the pons Varolii and the flocculi. The apparent origins of the fifth nerves are seen at its sides.

The *cerebellar portion* lies on the sides of the medullary and the pontal portions, and answers to the basal aspect of the cerebellum, excepting the flocculi.

The *crural portion* lies between the pontal and the cerebral portions. It represents the basal aspect of the stem of the brain as it lies uncovered by the pons. Each crus forms the *crusta* or *foot of the cerebral peduncle*, which passes forward and slightly outward, and is more or less rounded, elongated from behind forward, flattened from within outward, and marked by a few longitudinal linear depressions. Each crust is bounded in front by the optic tract and the corpora albicantia. Between the crura cerebri is a small median depressed space pierced by a number of minute openings for bloodvessels, which has received the name of the *posterior perforated space* (interpeduncular space).[1]—The third nerve arises from the median border of the crus cerebri of its own side; winding round the lateral border of the crus is the trunk of the delicate fourth nerve.

The *cerebral portion* is that part of the base lying in advance of the crural portion.

The interval between the tips of the temporo-sphenoidal lobes is occupied by the crura cerebri already described, and by the floor of the third ventricle with its associated parts.

The occipital lobe is, of course, excluded from the base of the brain, since it lies above the tentorium.

Among the fissures of the base of the brain may be noted the beginnings of the fissure of Sylvius on each side, and anteriorly, in the median line, the longitudinal fissure. At the bottom of the fissure last named, a portion of the corpus callosum is seen. In front, the corpus callosum is incurved, and terminates in structures which are lost upon the base.

The remaining structures of the cerebral base, proceeding from before backward, are recognized in the following order:—

1st. The peduncles of the corpus callosum. These are two delicate white bands which diverge from the reflected part of the corpus callosum, each of which passes along the outer edge of the optic tract, and is lost in the beginning of the fissure of Sylvius. Between them is a shallow longitudinal groove; crossing this groove on a level with the posterior edge of the frontal lobe, is, according to Henle, a small band of gray matter called by him the *white basal commissure.*

2d. The anterior perforated spaces. These are two in number, one on each side, between the anterior border of the optic tract and the beginning of the fissure of Sylvius. They answer to the bases of the corpora striata, and are marked with numerous punctate openings for the passage of bloodvessels to these bodies.

3d. The olfactory bulbs. These will be described under the cranial nerves. The three roots of the olfactory nerves are found in relation to the anterior borders of the anterior perforated space. The outer root is a white streak; the middle root is of a pyramidal figure, and of a gray color; the inner root is of a white color, and is directed to the inner and the posterior part of the anterior cerebral lobe.

4th. The *lamina cinerea*, the *tuber cinereum*, and the *pituitary body*. These structures lie in the median line, and relate to a region extending from the

[1] The interpeduncular space, according to some writers, extends forward as far as the optic chiasm.

posterior plane of the edge of the corpus callosum to the line of the optic tracts as these structures limit the anterior borders of the crura cerebri. The lamina cinerea and the tuber cinereum are thin laminæ composed for the most part of gray matter, and make up the floor of the third ventricle. They are displayed without dissection, except opposite the temporo-sphenoidal lobe, where they are covered by the optic chiasm as it crosses the median line. The *lamina cinerea* lies directly in front and slightly above the optic chiasm. The *tuber cinereum* lies beneath and somewhat behind it, being prolonged downward into a funnel-shaped process—the *infundibulum*—which extends forward, parallel with the optic nerves, and terminates in the pituitary body. The *infundibulum* is hollow, the lining membrane of the third ventricle being continued into it.

The *pituitary body* is a solid structure, and presents a complex organization. It is a bean-shaped vascular mass, broader than it is long, and is received within the pituitary fossa of the sphenoid bone. It is held in position by the dura mater, and is surrounded by the circular sinus. Beyond it, laterally, lies the cavernous sinus, and behind it is the *dorsum sellæ*. The pituitary body weighs from five to twenty grains. It is composed of two portions, an anterior or frontal lobe, and a posterior lobe.—The anterior lobe is the larger and more vascular of the two; it is of a grayish or yellowish color, and is concave posteriorly for the reception of the posterior mass. It is composed of a coarse network of connective tissue, in which are defined crypts or cells filled with a colloid substance, recalling that obtained from the thyroid body.—The posterior lobe is of a reddish hue, and is composed of gray nerve-matter which is continuous with that of the infundibulum and lamina cinerea.

5th. The *corpora albicantia*, or mammillary eminences, are two in number, one on either side of the median line, just behind the *tuber cinereum*. They represent the free ends of the anterior pillars of the fornix, and contain gray tissue within, while composed of white tissue without; the latter structure being alone in common with the fornix. The central gray matter is continuous with that found in the third ventricle.

6th. The *optic tract and chiasm*. The optic tract, as it turns round the end of the crura on either side, becomes a part of the base of the brain. It lies upon the fibres which posteriorly are continuous with the crus cerebri, and anteriorly pass beneath the tip of the temporo-sphenoidal lobe. The general position of the chiasm has been already given.

THE MINUTE ANATOMY OF THE BRAIN.

At the risk of occasionally repeating the statement of a fact in the preliminary paragraphs, the minute anatomy of the brain will be considered in the following order:—

The Connective Tissue Matrix.
The Central Canal.
The Nerve-Cells.
The Nerve-Fibres.
The Bloodvessels.
The Lymph-Spaces.

The Connective Tissue Matrix.—The connective tissue matrix is a less conspicuous formation in the brain than in the spinal cord. Neuroglia can, however, be detected in the cortex of the cerebrum—especially in the first and fourth layers; in the olfactory bulb; in the optic tract; in the crura cerebri; in the nucleus of the olivary body, and in the continuation from the spinal cord into the medulla oblongata of the posterior gelatinous substance.

The ependyma is covered with cilia in young individuals, and lines the ventricles and communicating passages of the brain.

The Central Canal and its Nerve-Cells.—The gray matter of the cord may be considered to be a collection of nerve-cells about the central canal (tubular gray substance), and is thus homologous (apart from the central gelatinous substance, which is present) with the mass about the central canal of the medulla oblongata before the formation of the fourth ventricle, with the gray matter lying at the floor of the same, and with the gray matter of the *iter*.

The Nerve-Cells of the Brain are collected in separate layers or groups in the following localities: The medulla oblongata, the pons, the cerebellum, the crura cerebri, the corpora quadrigemina, the optic thalamus, the striated body, and the cerebral cortex.

The Nerve-Cells of the Medulla Oblongata.—In describing these nerve-cells, the following determinations of the transverse planes of the structures within which they lie will prove useful. The medulla can be conveniently divided into three portions, the lower, middle, and upper. The lower border is usually said to begin at the plane of the foramen magnum. According to W. Krause, the lower portion begins at the plane of the first cervical nerve and even the second. It may be said to extend to the plane of the lower border of the olivary body. The middle portion corresponds to the planes of the lower and upper borders of the olivary body. The upper portion lies between the plane of the upper border of the olivary

body and the plane of the middle of the floor of the fourth ventricle. In general, however, the upper portion may be said to answer to the medullary portion of the fourth ventricle, while the middle and lower portions inclose the central canal. Since the upper portion of the fourth ventricle advances beyond the lower border of the pons, the uppermost of the sections through the ventricle have received the name of the *pontal sections of the fourth ventricle.* The exact position of any plane of the medulla oblongata is sufficiently described by lines or centimetres, in the portions as above defined.

The nerve-cells of the medulla oblongata are found in locations which are in great part continuous with the gray matter of the spinal cord. The posterior horn is withdrawn from the close relation it held to the periphery, and is covered by fibres derived from the lateral columns. It furnishes nerve-cells which form the nuclei of the restiform body (*nrb*, Fig. 103, *nrs*, Fig. 104), the postero-median column (*pmc*, Fig. 103), (nucleus of Goll), and the postero-lateral column (*plc*, Fig. 103), funiculus cuneatus (nucleus of Burdach). The posterior gelatinous substance is retained (*sg*, Fig. 103) (gelatinous nucleus) in the region of the restiform body and to the median side of the ascending root of the fifth nerve. It also, in the opinion of some writers, enters into the composition of the sinuate nucleus and of the associated nuclei of the olivary body.

The central gelatinous substance, together with the central gray matter, composes the gray matter at the floor of the fourth ventricle, where it accommodates the nuclei of the twelfth, tenth, ninth, and in part the eleventh, eighth, and seventh nerves. A nucleus is found to the median side of the anterior pyramid, which is continuous with nerve-cells of the anterior spinal cornu. Gray matter (reticular ganglion) is also found in the interstices of nerve-fibres, constituting the raphe and the reticular substance.

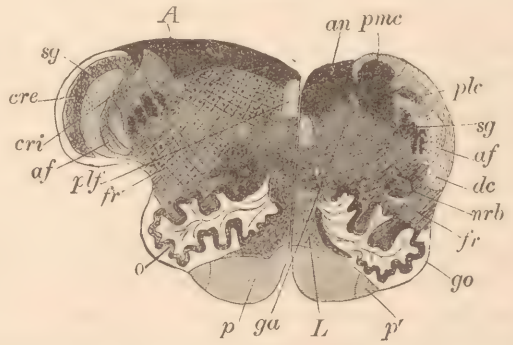
The olivary nuclei are three in number: the *olivary nucleus proper* (dentate body) (*o*, Fig. 103, *io* and *o*, Figs. 104, 105) or inferior olivary body of Meynert, the *outer accessory olivary nucleus* (external olivary body of Meynert), and the *inner accessory olivary nucleus* (internal olivary body of Meynert) (o^1, o^2, Fig. 105). These names indicate their relative position to the main nucleus or body.[1]

The nuclei in the floor of the fourth ventricle are the following: the hypoglossal nucleus, composed of large multipolar cells, descends to the outer side of the median groove; continuous below, according to Schwallbe, with the central gray matter of the spinal cord, and, according to Clark and Meynert, with the intermediary lateral tract of the spinal cord, is a columnar tract of gray matter (nuclear column) lying to the lateral aspect of the hypoglossal nucleus; above, it is overlapped by the auditory nucleus, and is continuous below with the central gray matter of the spinal cord. Within this mass are two distinct groups of small cells; the median of the two (vago-accessory of Spitzka) is usually described as yielding two nuclei, one for the eleventh, and one for the tenth nerve. The eleventh nerve is continuous with the intermediary lateral tract of the spinal cord; the lateral group forms the nucleus of the ninth nerve. The nucleus for the nerve of Wrisberg is supposed by some writers to lie within the nuclear column.

A little anterior to the last-named mass, and lying in the subendymal nerve-mass, is the main auditory nucleus for the eighth nerve; the accessory auditory nucleus and the ganglion on the main nerve-root being found lower down. The nucleus is best seen in a section made through the plane of the medullary striæ.

Adjacent to the auditory nucleus is the main nucleus for the seventh nerve.

Fig. 103.



A diagrammatic frontal (transverse) section of the medulla oblongata. The right half of the section is at the level of the middle of the olivary body, the left half at the level of the upper portion of the olivary body, and near the inferior border of the pons Varolii. *L*, interolivary tract; *p*, anterior pyramid; *g a*, common ascending root of the lateral mixed system; *p'*, position of fibres from the anterior pyramid which join the restiform body; *o*, olivary nucleus; *f r*, reticular formation; *p l f*, posterior longitudinal fasciculus; *a f*, ascending root of the fifth nerve; *c r i*, inferior cerebellar peduncle; *s g*, substantia gelatinosa posterioris (tubercle of Rolando); *A*, the posterior of the acoustic nuclei; *a n* hypoglossal nucleus; *p m c*, postero-median column; *p l c*, postero-lateral column; *d c*, direct cerebellar column; *n r b*, nucleus of the restiform body.

The reticular gray matter (reticular ganglion) (*fr*, Fig. 103) is the name given to the nerve-cells in the masses of the reticular formation. It is continuous above with the cells of the tegmentum, and below probably with the gray matter of the spinal cord. The gray matter accommodates the nuclei of the ninth, tenth, and eleventh nerves. E. C. Spitzka assigns to it in part the motor root of the pneumogastric nerve.

The gelatinous substance, while not cellular, ap-

[1] The words nucleus, gray matter, and body are frequently used in the same sense. Nuclei are localized masses of gray matter. The term body is often reserved for a nucleus which projects from the surface of the anatomical figure of which it forms a part, and is covered with white matter. The terms, olivary body, olivary nucleus, and olivary gray matter may be used synonymously.

pears in two places in the medulla: one, the central gelatinous substance, at the floor of the fourth ventricle, already named under the consideration of the central gray matter; and the other, the posterior gelatinous substance, in the *tubercle of Rolando* (*sg*, Fig. 103), which forms the mass lying beneath the lateral aspect of the medulla, at the direct cerebellar tract. It here forms on the periphery of the medulla a columnar eminence, which is sometimes known as the *column of Rolando*.

The Nerve-Cells of the Pons.—These comprise the cells inclosed in the meshes of the *formatio reticularis*, and in a special nucleus named by Rollet the *nucleus centralis*. The gray matter surrounding the iter may be said to be part of the system of the subendymal nerve-mass, homologous with that about the spinal and medullary central canal already mentioned.

The Nerve-Cells of the Cerebellum.—The cortex of the cerebellum differs greatly from the cortex of the cerebrum in complexity. It presents some distinctive cellular structures, as follows:—

(1) An outer clear layer composed of nerve-substance, and containing here and there a connective-tissue corpuscle, with a large number of distinct, small, roundish corpuscles.

(2) A single layer of cells known as the cells of Purkinje. These are relatively large, elliptical, or flask-shaped cells retaining remarkable filamentous processes projected from the outer extremity. These processes, commonly single at first, soon give off numerous parallel, or nearly parallel, rays, which have been compared to the hairs of a brush, and to the ribs of a leaf. The inner extremity of each cell yields commonly but a single relatively small process.

(3) A grayish layer composed of a matrix, interspersed with a plexus of minute nerve-fibres, the whole associated with great numbers of roundish corpuscles.

The outer surface of the cortex is intimately associated with the investment of pia mater by means of minute bloodvessels which pass into the outer gray layer. Henle describes peri-vascular lymph-spaces about the cortex.

Near the centre of the cerebellum is an elliptical nucleus called, from its abruptly sinuate margin, the *dentate body*. It is of a dark, yellowish color, and is open in front to allow the exit of the medullary matter within. Fibres pass from it to the superior cerebellar peduncles.

Meynert describes an accessory dentate nucleus situated below and in front of the dentate body proper. A third nuclear centre, composed of two small nuclei, is found in the inferior vermiform process, as it forms the roof of the fourth ventricle, forming the nuclei of the *fastigium*.

The Nerve-Cells of the Stem of the Brain.—The principal nucleus of the region of the crus cerebri is the *locus niger* (*locn*, Figs. 109, 110, 111, 112) (substantia niger, gray matter of Sömmering). This large collection of nerve-cells is continuous below with the gray matter of the reticular substance of the pons Varolii, and extends between the crusta and the tegmentum as far as the optic thalamus, where it ends near the *body of Luys* (Fig. 112). It is remarkable for possessing a number of dark pigment-cells, and is imperfectly defined on its tegmental border, where the reticular substance accommodates some of the cells. The crus also yields the nucleus for the origin of the third nerve.

The nerve-cells of the corpora quadrigemina, optic thalamus, and related parts embrace the nuclei in the anterior tubercles, in the geniculate bodies, and in the posterior tubercle, and the nuclei of the optic thalamus. The cells in the anterior tubercle are continuous with those of the optic thalami. Upon the surface is a thin medullary layer, and beneath a thick layer belonging to the *iter*. The cells of the *geniculate bodies* resemble in general features those of the gray matter of the optic thalamus. The outer of the two presents on section a coarsely laminated appearance. It lies between the tail of the caudate nucleus and the thalamus. The cells of the posterior tubercles relate chiefly to the reticular formation of the tegmentum.—Modern writers describe a group of fibres passing radiately from the corpora quadrigemina to the occipital lobe near the terminal posterior fibres of the corpus callosum. There thus exists, according to Charcot,[1] a direct relation between these fibres and the frequent coexistence of symptoms such as hemi-anæsthesia and crossed amblyopia; the former being referable to the cerebrum, and the latter to the optic tract.

At the region near the optic thalamus and the corpora quadrigemina, the nerve-cells are arranged in two groups, which may be regarded as part of the same system with the tegmental system of fibres. These nuclei have received the names of the red nucleus and the body of Luys. The *red nucleus* (nucleus of the tegmentum) (*rn*, Figs. 109, 110, 111, 112), the larger of the two, is circular in section. The *body of Luys* (*cL*, Fig. 112) is elliptical in section. Near and in front of the locus niger, but not continuous with it, is the border of the thalamus. Between

[1] Leçons, 134.

the optic thalamus and the lenticular nucleus, and thence to the base of the brain, is an association of fasciculi known as the *substantia innominata.* It yields two band-like structures, the *superior* and *inferior peduncles of the thalamus.*—An imperfect division of the thalamus into segments is seen in the formation known as the *laminæ medullares* (*th*, Fig. 112).—A thin layer of nerve-cells lines the third ventricle at the median margin of the thalamus. The middle commissure, according to this interpretation, does not unite the thalami, but the cells lining the sides of the third ventricle.—Beneath the pineal peduncle is found a small nucleus, which is distinct from the thalamus, and is named the *habenule* (habenula). Fibres pass from it to the outer side of the thalamus, through the tegmentum. The details of the minute anatomy of the thalamus are exceedingly complicated, and cannot be abridged with advantage. —In the anterior part of the thalamus is a distinct nucleus, which has received the name of the *nucleus of the anterior tubercle.* The cells in the pulvinar of the thalamus lodged at the mouth of the descending horn of the lateral ventricle connect the thalamus with the nuclei of the optic mechanism. It is in a strict sense a member of the quadrigeminal group. The thalamus is penetrated by the nerve-fibres of the *lamina medullaris*, by the *stratum intermedium*, by the posterior longitudinal fibres, by the legs of the fornix, and by the anterior commissure.

The Nerve-Cells of the Striated Body.—The striated body is composed of the lenticular and the caudate nuclei. The *lenticular nucleus* (*ln* I, ii, Fig. 112) fig. 1, Plate LXXII., is of a wedge shape, with the base of the wedge directed forward and toward the island of Reil. Upon transverse section through its anterior and middle portions, the caudate nucleus is seen to its inner and the claustrum to its outer side.

The *caudate nucleus* (*cn*, Fig. 112) is a conspicuous mass larger in front than behind. The *claustrum*, although situated on a deeper plane than the island of Reil, and in a measure concentric with it, and embraced within the figure of the striated body, is best included in the account of the cortex, which it resembles in structure.

The Cortex of the Cerebrum.—The cortex of the cerebrum is composed of five layers numbered from without inward.[1]

The first layer is of a pale color, and composes about one-tenth of the thickness of the cortex. It is composed of small scattered inconspicuous corpuscles in abundant neuroglia.

The thickness of the second layer is about the same as that of the first, or is somewhat greater; it is occupied by small close-set pyramidal corpuscles and nuclei, the former having pronounced prolongations at the angles.

The third is the thickest, most constant, and most characteristic of the layers. It is somewhat paler than the preceding, and is made up of large pyramidal corpuscles with produced and exaggerated filaments. Between these the neuroglia becomes fibrillated, and passes in delicate fasciculi from this to the succeeding layers. The third layer is held to be homologous with the multipolar cells of the anterior horn of the gray matter of the spinal cord, and with the nuclei of the motor cranial nerves.

The fourth layer is thin and composed of close-set granule like corpuscles. It is in this layer that few, but the largest pyramids of all are found.

The fifth layer (ganglionic layer, Lewis) is a small relatively compact layer of fusiform corpuscles. It gradually merges into the medullary tract of the cerebrum.

The most important of the modifications of the cortex are seen between the cortex at the island of Reil and the lenticular nucleus. At this portion of the brain a thin nucleus-like structure is seen which has received the name of the *claustrum.* According to Meynert, "a vertical transverse section of the claustrum presents the form of an arched cone with its base below. This lower enlargement forms the most compact mass where the claustrum penetrates the temporal lobes over the base of the insula. Here, constituting the anterior limit of the descending cornu of the lateral ventricle, and formed from the elements of the claustrum, is a rounded mass, the *amygdaloid nucleus.* This, by means of a series of transitional masses, may be regarded as belonging to the claustrum." Vicq. d'Azyr ascertained that the occipital lobe presented a feature peculiar to its cortex, being divided into two secondary layers separated by a white layer. This white layer (which is really composed of two white lines) is sometimes mentioned by clinical writers as the *riband of Vicq. d'Azyr.*

Meynert describes solitary cells in the white line—layers of the occipital lobe.

According to Betz,[1] the cells of the posterior or sensory region of the cortex are smaller than those of the anterior or motor region, and have a rudimentary form in the third layer of cells. On the other hand, it is interesting to note

[1] Some writers (Baillarger, Clark, Lewis) divide the fifth layer into two portions, thus making six layers for the entire cortex. W. Krause adds a seventh layer composed of exceedingly small stellate, pyramidal, and fusiform cells lying upon the medullary matter.

[1] Centralblatt f. d. Wissenschaft. Medecin., 1874, Nos. 37, 38.

the disposition of the large cells in the fourth layer of the cortex in the fissure of Rolando, the convolutions bordering upon this fissure, and the posterior portion of the third frontal convolution.

Stratum of Remak. Under this head is described a thin layer of medullated fibres (fibres of Remak) lying beneath the first layer of the cerebrum.

For detailed accounts of the minute structure of the brain, the student is referred to the following sources:—

Meynert, Theodore, The Brain of Mammals; Stricker's Manual of Histology, 1874; Skizze des Menschlichen Grosshirnstammes, etc., Archiv für Psychiatrie, iv. 1873, 387; Huguenin, Gustav, Allgemeine Pathologie der Krankheiten des Nervensystems, Archiv für Psychiatrie, 1875, v. 344; also the résumés of Paul Berger, Archiv. de Physiologie, 1874, 383; J. M. Charcot, Leçons sur les Localisations dans les Maladies du Cerveau, Paris, 1876; and the writings of E. C. Spitzka in Journal of Nervous and Mental Diseases.

THE NERVE-FIBRES.

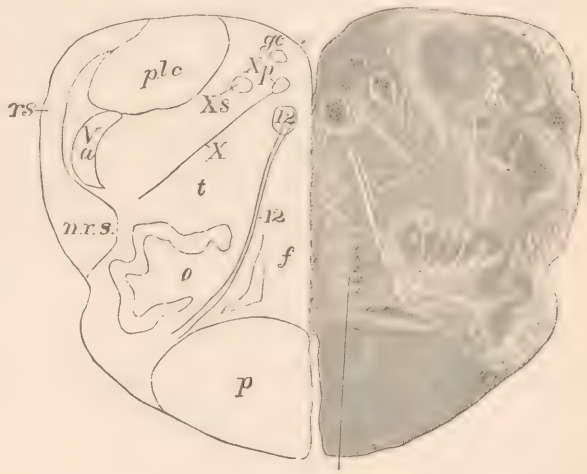
The Nerve-Fibres of the brain unite the separate masses of nerve-cells of the brain and of the spinal cord, or pass into the efferent nerves. Their arrangement, as far as it has been detected, is of great intricacy, and much difference of opinion exists in regard to it.

The nerve-fibres of the brain are those which pass upward from the spinal cord, or the *centripetal;*[1] those which pass downward to the spinal cord, or the *centrifugal;* those which are recognized as connecting groups of nerve-cells not contained in the systems named above, or the *commissural;* and those which make up *the intrinsic fibres of the cranial nerves.*

The centripetal nerve-fibres end in the medulla oblongata, the thalami, the corpora quadrigemina, the cerebellum, and possibly in the occipital lobes of the cerebrum. Flechsig defines a tract in the crus, derived from the transverse fibres of the pons, which passes to the corpus striatum and the frontal lobe of the cerebrum. The centrifugal fibres can be traced from the cortex of the brain to the spinal cord by way of two bi-lateral tracts of great importance, which may be known as the tract of the crusta and the anterior pyramids, from the fact that they are exposed upon the crus cerebri and upon the periphery of the medulla oblongata at the anterior pyramids. The commissural fibres are confined for the most part to the cerebrum. While the above arrangement will be followed in describing the nerve-fibres, it must be acknowledged that some fibres exist which cannot be made to conform to it. It will be accepted, however, as the most satisfactory plan; but until a greater uniformity of opinion prevails, it is best to follow a topographical method in the presentation of facts, with an occasional emphasis on data presumably of morphological or functional value.

[1] The terms centrifugal and centripetal relate to the direction of physiological transmission of nerve-force.

Fig. 104.



Section of the medulla oblongata at the level of the hypoglossal nucleus; four times enlarged. The plane of division of the fourth ventricle is below the pontal portion; *g c*, central gelatinous substance; *Xp*, posterior pneumogastric nucleus; *Xs*, superior common root of the same; 12, hypoglossal nucleus and intrinsic fibres; *p l c*, postero-lateral column; *r s*, restiform body, including the direct cerebellar tract; *n r s*, nucleus of restiform body; *o*, olivary nucleus and body; *f*, (the L-shaped fibres near the hypoglossal fibres) fillet; *p*, anterior pyramid; *V a*, ascending root of the fifth nerve; *t*, tegmental reticular continuation.

The fibres of the medulla oblongata (Fig. 104). The *centripetal nerve-fibres* are traced from the spinal cord into the medulla oblongata, and the cerebellum, by the postero-median and postero-lateral columns, and by the direct cerebellar tracts. The fibres of the postero-median column form the fibres of the funiculus gracilis. The majority of observers believe they terminate here, but some, as E. C. Spitzka, trace them up to the intermediary system after interruption in the nucleus of the column of Goll.

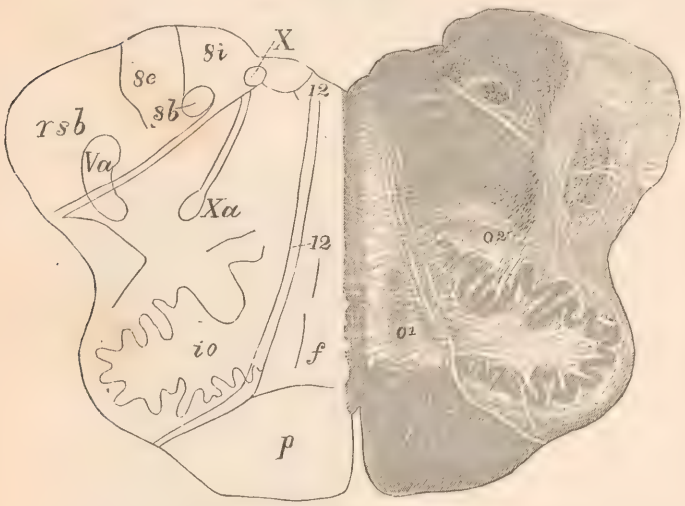
The fibres of the postero-lateral column divide into two sets, one of which assists in forming the restiform body, the other passes to the intermediary system (pinniform decussation, sensory decussation) and the raphe.

The fibres of the direct cerebellar tract assist in forming the restiform body.

The restiform body is composed of fibres of the direct cerebellar tract and part of the postero-lateral tract. As already seen (p. 465), it contains a prolongation of the posterior gelatinous substance of the spinal cord. The fibres of the restiform body are embraced by

the posterior pair of intrinsic nerve-bundles of the acoustic nerve.

Fig. 105.



Section of the medulla oblongata through the acoustic nuclei at the floor of the fourth ventricle, four times enlarged. The plane of division of the fourth ventricle is below the pontal portion; *X*, pneumogastric nucleus; the lenticular figure to the median side of *X* is the eminentia teres; 12, intrinsic hypoglossal nerve-fibres; *8i*, *8e*, internal and external acoustic nuclei; *f*, fillet; *io*, inferior olive; *p*, pyramid; *Va*, ascending border of the fifth nerve; *rsb*, restiform body; *o1*, *o2*, accessory olivary nuclei; *Xa*, portion of the intrinsic fibres of the pneumogastric nerve.

The commissural and plexiform fibres of the medulla are of great importance and intricacy. They arrange themselves under the following heads: the raphe; the fibres of the reticular substance; the intermediary system; the arciform fibres.

The *raphe* is a median group of nerve-fibres beginning in the medulla oblongata, and extending through the pons Varolii and the stem of the brain as far as the posterior commissure. It is composed of straight fibres (fibræ rectæ) and arcuate (decussatory) fibres. It receives the terminal fibres of many of the centripetal tracts from the spinal cord, the fibres of the posterior longitudinal fasciculus, and of the fillet. With the reticular formation, it is supposed to hold important relations to speech and facial expression.—The region of the raphe is of great interest, since here in the median line the reticular formation remains in an undifferentiated state. The raphe, indeed, is the dividing line between the right and left parts of the beginnings of systems of fibres pertaining to sensation. The fibres of the fillet or the *optic fibres*, the fibres of the auditory nerve, in part, or *auditory fibres*, the fibres of the fifth nerve or *trigeminal fibres*, probably all have their origin in part in gray matter at the raphe. The raphe contributes to the fibres of the trineural fasciculus, or the *fibres* of the *ninth*, *tenth*, *and eleventh cranial nerves*. It is crossed by the fibres decussating between the olivary nuclei, and by the pinniform decussation of the postero-median columns. Both superficial and deep arciform fibres connect with it.

The fibres of the *reticular formation* (reticular substance, formatio reticularis) embrace the same part as the raphe, and cannot in all respects be separated from it. The reticular formation is an arrangement of interlacing bands; beginning in the medulla oblongata and extending through the pons and crura cerebri. It is composed of longitudinal and transverse fibres, holding in the interstices formed by their interlacing, numbers of nerve-cells; these nerve-cells are in part derived from and continuous with those of the lateral cornua and the reticular processes of the spinal cord. The fibres of the reticular formation at the crus cerebri pass into the tegmentum, which is thus seen to be a part of a strictly encephalic system of fibres.

The *intermediary system* (interolivary layer) is the name given by Flechsig to a system of fibres lying between the olivary bodies, but composed in the main of longitudinally disposed fibres. It is intimately associated with the terminal portion of the fillet, and sends out fibres which are mingled with those passing upward to the dentate nucleus of the olive. It also derives numbers of important fibres from the posterior lateral columns, and is connected with fibres from both the tegmental and pedal tracts.

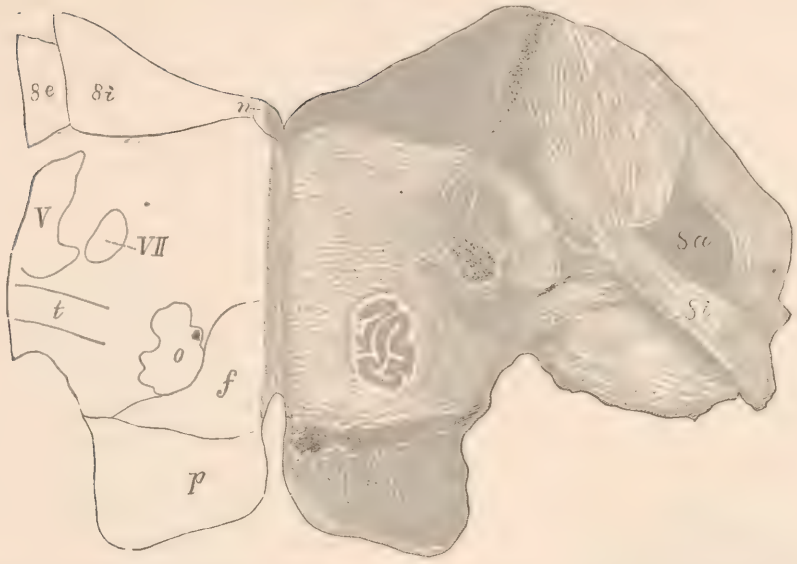
The *arciform fibres* (arcuate fibres) are arranged in two sets, a superficial and a deep. The *superficial fibres* lie near the anterior aspect of the medulla, and are in part exposed upon it. As they pass over the olivary body, they receive the name of the *siliqua olivæ*. They are derived from the raphe, and cannot at all points be separated from those of the *deep set*, which have been traced from the raphe to the cerebellum, to the nerve-cells of the restiform body, and to the cuneate and slender funiculi of the opposite side of the medulla.

The longitudinal fibres of the stem of the brain which end in the medulla oblongata are fibres of the fillet and of the posterior longitudinal fasciculus.

The *fibres of the system of the fillet*, so named from the fact that they are exposed to form the fillet near the posterior pair of the corpora quadrigemina, arise, according to Roller and some other observers, from near the raphe of the medulla oblongata. According to Spitzka, they arise from the spinal cord at the side of the antero-median column.

These fibres are in close relation with those of the crusta and anterior pyramid, if not continuous with them. As the tract of the fillet passes upward, it joins

Fig. 106.



Section of the medulla oblongata through the level of the posterior auditory roots, four times enlarged. The plane of division of the fourth ventricle is below the pontal portion; *n*, median nucleus; 8*a*, anterior acoustic nucleus; to its outer side lies the direct cerebellar tract; 8*e*, external acoustic nuclei; 8*i*, internal auditory nucleus and nerve-fibres; *V*, fifth nerve; *VII*, nucleus of the facial nerve; *t*, trapezoid fibres; *o*, olive.

the longitudinal fibres from the lower olivary nucleus, and in the pons divides into two sets of diverging branches, one of which (the lower fillet) joins the fibres of the crusta and of the anterior pyramid at the median border of the crusta, the other of which (upper fillet) passes obliquely upward and outward to become superficial at the median border of the crusta,

Fig. 107.



Section of the pons Varolii at its lower border, twice enlarged. The plane of division of the fourth ventricle is, of course, through the pontal portion; *crp*, posterior cerebellar peduncle; *rb*, restiform body; *cm*, middle cerebellar peduncle; *tb*, trapezoid bundle; *VII*, facial bundle; *VIII*, acoustic nerve-fibres; 8*e*, external acoustic nucleus; *Va*, ascending bundle of the fifth; f^1, fillet; *P*, fibres of the crusta and anterior pyramid; *pV*, superficial transverse fibres of pons Varolii.

near its termination, and at the inner edge of the locus niger. B. Stilling claims that the optic tract is directly continuous with the fillet. This set ends in the anterior tubercle of the corpora quadrigemina, where its fibres probably decussate. The fillet is thus a system of great intricacy, and is an outgrowth of the main stem of the cerebro-spinal fibres, having special diverticuli received from the inferior portion of the olive and from the corpora quadrigemina.

Schwalbe[1] gives an elaborate tabular illustration of the fibres of the fillet.

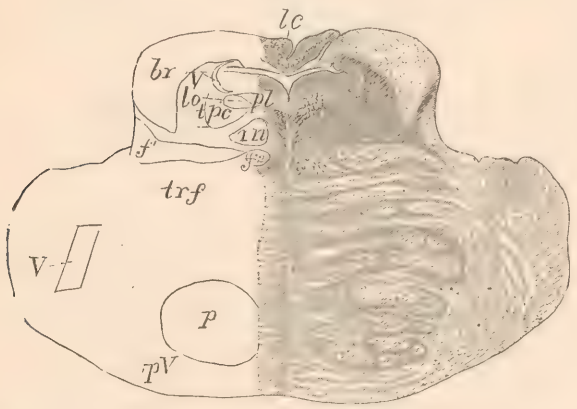
The *posterior longitudinal fasciculus* is a narrow band of fibres near the median line of the floor of the fourth ventricle, formed by the aggregation of some of the longitudinal fibres of the reticular substance. It is supposed for the most part to be commissural between the nerve-cells of the nuclei of the third, fourth, and sixth nerves, and the corpora quadrigemina. It has been traced to the raphe by Roller, and by Spitzka to the anterior cornu of the spinal cord.

The *trapezial fibres* form a delicate fascicle in the pons Varolii in the region of the reticular substance. The fibres of the fascicle are disposed obliquely to the sagittal (longitudinal) section of the medulla, on a level with the posterior end of the pons, and cross the intrinsic fibres of the sixth and seventh nerves. Their ultimate destination is unknown, though they are in relation with tegmental fibres. The trapezial fibres are rudiments of that extensive system found in many lower mammalia, whose fibres form the conspicuous body on the anterior surface of the stem of the brain, called the *trapezium*, and which finally end in the cerebellum at the vermis.

[1] Neurologie, 645.

The origin of the cranial nerves, including their intrinsic fibres.—Since all the cranial nerves, with the exception of the first, the second, the third, the fourth, and part of the eleventh, arise within the medulla oblongata, their consideration appears under the section treating of the minute anatomy of that part of the brain; for further description, see Cranial Nerves. The cranial nerves having apparent origin from the medulla, arise from nuclei answering to the region of the floor of the fourth ventricle, and, of course, upon the posterior aspect of the medulla; still, according to Spitzka, arising from the neighborhood of, if not directly from nerve-cells within the central gelatinous substance.

Fig. 108.



Section of the stem of the brain at the pons Varolii, and of the superimposed parts at the level of the lingula of the cerebellum; *l c*, lingula. The space beneath the lingulæ is the iter; *br*, brachial process; *V*, ascending root of the fifth nerve; *lo*, locus cæruleus; *p l*, posterior longitudinal fasciculus; *r n*, red nucleus; f^1, fillet, lying exposed in part; f^2, slip to fillet from the pyramidal tract; *tr f*, transverse deep fibres; *p*, fibres of the crusta and the anterior pyramid.

The degree in which the intrinsic nerve-bundles assist in making up the bulk of the medulla and stem of the brain is unknown. When the great extent and intricate association of these nerves are considered, especially of the fifth and tenth nerves, it is evident that in the study of lesions or foci of degeneration the effect of direct injury to the intrinsic nerve-fibres must play an important role in the causation of symptoms.

The two nuclei of the eleventh nerve lie in the interval between the olivary nucleus and the ascending root of the fifth nerve.

The first nerve seen after the eleventh is the twelfth, which is visible at the lower border of the olivary body. It traverses the plane of the medulla from the nucleus near the median line to the lateral border. The nerve-cells of the nucleus are large and multipolar.

At the level of the lower border of the upper portion of the medulla, the restiform bodies are seen clearly outlined. The ninth and tenth nerves take their apparent origin between this body and the olivary body, and traverse the section obliquely from the nuclear mass of origin at the floor of the fourth ventricle.

Under the name of the trineural fasciculus of Spitzka (round bundle, solitary bundle, respiratory fasciculus) is described a cylindrical group of nerve-fibres lying beneath the ala cinerea and the subendymal auditory nucleus. The afferent fibres are derived from the raphe. The efferent fibres form the roots of three nerves, the glosso-pharyngeal, the pneumogastric, and the spinal accessory.

The region of the Pons Varolii, Crura Cerebri, and the Corpora Quadrigemina.—The fibres of this region, or those of the stem of the brain, are best studied in the planes of frontal (transverse) sections. Each plane receives its name from the part exposed at the base of the skull. Thus a section of the pons, of the crura, etc., implies a section of all the parts of the stem lying above the pons, that is to say dorsally to the crura. By comparing the descriptions of the various bundles of fibres with Figs. 107 to 111, it will be found that the stem of the brain is composed of longitudinal, transverse, and oblique fibres which serve to unite the cerebellum and the medulla oblongata with the cerebrum.

Among the fibres may be separately named those of the crusta, those of the tegmentum, and those of the fillet.

The longitudinal fibres are seen in the fillet (f, f^1), which, at the lower border of the pons, lies above the tract marked *p* near the raphe, but soon curves obliquely and expands laterally from the raphe to the position of the intrinsic fibres of the seventh nerve. As the fillet approaches the upper part of the pons, it becomes narrowed and limited laterally by the root of the fifth nerve.

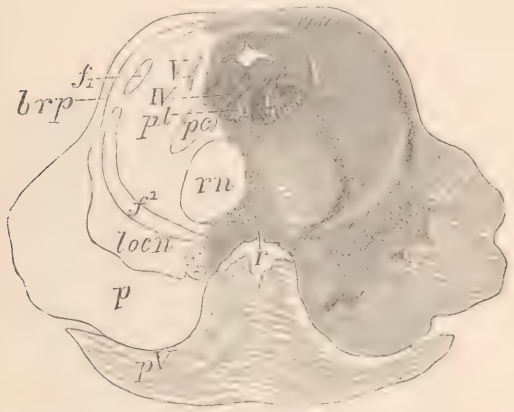
At the region of the brachial processes of the corpora quadrigemina, the fillet passes laterally, and is no longer in contact with the raphe. From above this point, the fillet again becomes concealed, passes beneath the posterior brachial process, contributes to the formation of the corpora quadrigemina, and is lost in the region of the optic thalamus between the red nucleus and the body of Luys.

The fibres of the crusta and the anterior pyramids.[1] This important and conspicuous mass of bundles (*p*,

[1] This name has been selected for this important group of fibres instead of the *pyramidal tract*, since the latter term has been restricted by clinicians to a portion of the internal capsule (see p. 498).

Figs. 104 to 112) is best studied centrifugally; *i. e.*, by beginning with the tract at its appearance in the crura cerebri, at the point where each crus is crossed by the optic tract, and tracing it toward the medulla oblongata. The tract is confined to the crusta. The crusta (basis cruris, pes, or inferior level) is the same as the crus cerebri of gross anatomy. At about the

Fig. 109.



Section of the stem of the brain near its upper extremity, *i e.*, through the pons Varolii and the posterior brachial process; twice enlarged; *V*, ascending bundle of the fifth nerve; *IV*, nucleus of the fourth nerve; *p l*, posterior longitudinal fasciculus; *c p*, fibres of the posterior commissure; *r n*, red nucleus; *f* 1, superior fillet; *f* 2, bundle passing to fillet from crusta; *p*, fibres of the crusta and of the anterior pyramid at the crusta; *l o c n*, locus niger; *r*, raphe; *b r p*, posterior brachial process of the corpora quadrigemina.

place of apparent origin of the third nerve it sends from the median border a slip of contribution to the fillet. At the region of the pons Varolii it lies immediately above the superficial transverse fibres, and is at first exposed laterally, but at the middle of the pons it is concealed by the transverse fibres, and is seen to lie near the raphe as a cylindrical bundle. Near the posterior border of the pons it is traversed by the intrinsic fibres of the sixth nerve, and, being directly overlaid by the fillet, passes from the pons to the anterior pyramid, where, as has already been seen, it divides into two portions, one the *direct tract* from the antero-median column, and the other the *indirect tract*, forming a part of the lateral column of the spinal cord.

The fibres of the crusta are thought to have an association with different parts of the cerebrum. The lateral fibres are supposed by some to pass to the posterior part of the internal capsule, about the posterior third of the posterior limb, and thence to the occipital lobe. The median fibres pass to the knee of the internal capsule, and thence to the third frontal convolution, while the fibres placed between the median and the lateral portions pass to the internal capsule, making up the anterior two-thirds of the posterior limb, and thence pass to the convolutions bordering on the fissure of Rolando. It is an interesting fact, that these fibres are supposed by Meynert and Flechsig to represent the seventh and the twelfth nerve-roots.

The fibres of the reticular formation can be traced from the medulla oblongata to the locus niger, where, and in the part above it, they constitute the *tegmentum*, and overlie the region of the crusta. The word tegmentum is freely translated "hood," since its fibres form a hood or cap to the fibres of the pes. The tegmentum is lost above in the stratum intermedium of the optic thalamus, in the separate masses of nerve-cells there aggregated, and in the corpora quadrigemina. The fibres of the tegmentum, while freely interchanging among themselves, do not decussate. They are probably continuous with the antero-lateral column of the spinal cord.

Among other fibres of the stem of the brain may be mentioned: first, a bundle called *the loop of the lenticular nucleus*, whose inferior termination is unknown; and second, the *decussatory fibres of the posterior commissure.*

The fibres of the corpora quadrigemina are connected to the medulla by the fillet in part, and by the posterior and anterior brachial processes with the internal and external geniculate bodies. They also receive some of the terminal fibres of the tegmentum, and the fibres of the optic nerve.

The region of the Cerebellum.—The *cerebellar nerve-fibres* are deflected from the main stem of the cerebro-spinal fibres along the direct cerebellar tract of the spinal cord, and along the continuation upward of the postero-lateral column, which tracts together form the inferior cerebellar peduncle. In addition the cerebellar nerve-fibres aid in increasing the bulk of the stem of the brain by sending to it the superior cerebellar peduncles.

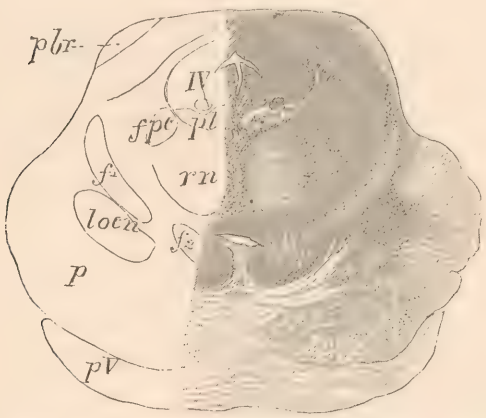
The medullary fibres of the cerebellum resolve themselves into the fibres of termination of the three peduncles. The flocculus yields a differentiated set of fibres, which pass upward over the acoustic nerves within the central gray matter of the fourth ventricle.

The region of the Cerebrum.—The nerve-fibres of the cerebrum embrace those of the centripetal tract, those of the centrifugal tract, those of the commissures, and the intrinsic fibres of the olfactory and optic tracts.

The *centripetal fibres* are in great part continuous with those of the tegmentum of the stem of the brain. The exact termination of such fibres is obscure, and little either of topographical or clinical value can be

said of them. They were formerly supposed to end in the optic thalamus, which body was held to be the great sensory ganglion of the brain. While this view is no longer tenable, it is certain that the tegmental fibres of the stem of the brain can be traced no further than to the plane of the hinder region of the thalamus, and possibly to the first segment of the lenticular nucleus. Much clinical evidence can be deduced to

Fig. 110.



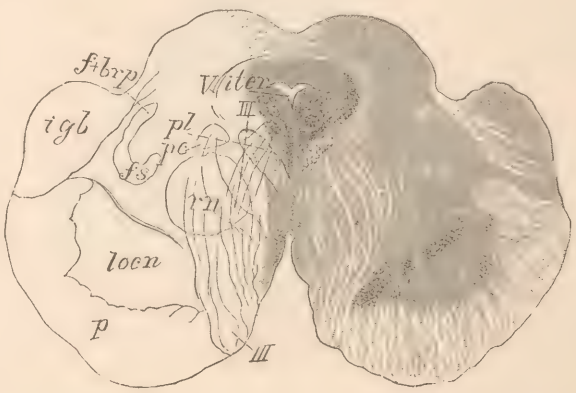
Section of the stem of the brain at the beginning of the pons Varolii near its upper border, twice enlarged; *p b r*, posterior brachial process; *p l*, posterior longitudinal fasciculus; *r n*, red nucleus; *f* 1, superior fillet; *f* 2, bundle from the crusta to the fillet; *p V*, pons Varolii; *p*, fibres of the crusta and of the anterior pyramid.

show that in some way the occipital lobes of the brain, probably by reason of their relations with the posterior parts of the thalami, receive some of the centripetal fibres. Under the name *occipital cerebral fasciculus*, Meynert describes a fasciculus which, in his opinion, is derived from the region of the postero-median and postero-lateral columns of the spinal cord, and is described as decussating a little in advance of the anterior pyramid, passing along the side of the crusta, and radiating directly within the occipital lobe to reach its cortex.

It has been already noted (pp. 493, 496) that the centrifugal tract, as it passes from the cerebrum to the spinal cord, forms a distinct bundle. This portion of the tract is of great clinical value, since it is found in the cerebrum to comprise in great part the nerve-fibres lying between the innermost or first segment of the lenticular nucleus, and the caudate nucleus in front, and the optic thalamus behind. From its relation to the inner or median aspect, by the lenticular nucleus, the fibre-mass containing this bundle is called its *internal capsule*. It is described, when seen in horizontal planes, as having an anterior and a posterior limb or segment, which are so inclined one to the other as to form an acute projection directed inward, called the *knee* (genu) of the internal capsule. The *anterior limb* lies between the anterior part of the lenticular nucleus and the caudate nucleus. The *posterior limb* lies between the posterior part of the lenticular nucleus and the optic thalamus.

It is found that the internal capsule is not a simple fasciculus of fibres, but that it is complex in character, and is composed of three parts, which answer

Fig. 111.



Section of the stem of the brain at the level of the posterior tubercles of the corpora quadrigemina, the internal geniculate body, and of the crura cerebri at the plane of the apparent origin of the third nerve; *iter*, iter; *V*, ascending bundle of the fifth nerve; *III*, intrinsic fibres of the third nerve; *f-brp*, fillet and posterior brachial process; *igb*, internal geniculate body; *locn*, locus niger; *p*, fibres of the crusta and of the anterior pyramid; *rn*, red nucleus; *fs*, superior fillet; *pc*, fibres of posterior commissure; *pl*, posterior longitudinal fasciculus.

to the median, the central, and the lateral parts of the crusta of the stem of the brain.—The *median part* is derived from the anterior limb, and receives its fibres from the central convolutions, and probably from all the frontal and the parietal lobes, and passes to the median portion of the crusta of the stem of the brain; the *central part* is derived from the knee, and passes to the central part of the crusta; and the *lateral part* is derived from the posterior limb, and passes to the lateral part of the crusta. The median part, the *pyramidal tract* of the clinician, is often found to be the seat of degeneration consequent upon lesion or degenerative changes, which have been found by L. Türck[1] and Charcot[2] to involve sometimes as much as a third of the crusta. According to the authority last named, the outer parts of the crusta are never involved in centrifugal degeneration.

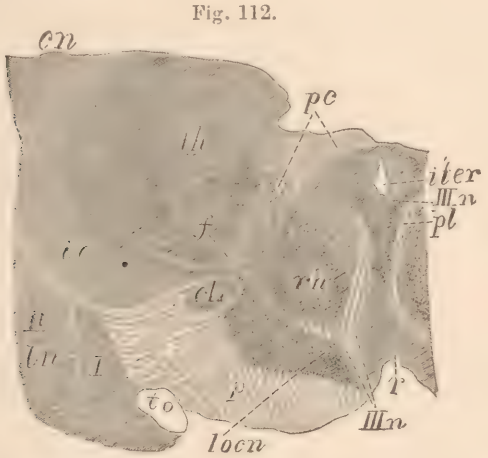
The centrifugal nerve-fibres of the cerebrum. The nerve-fibres of the cerebrum constitute the medullary or white substance of the cerebrum, and are composed of immense numbers of fasciculi, our knowledge

[1] Zeit. der k. k. Gesellsch. der Aert. zu Wien, 1850, I.; also Wien, Sitz. Bericht. 1851-1856.

[2] Progrès Médical, 1879.

possessed concerning the function of which is not in all respects exact. It is probable, however, that, with the exception of some of the fasciculi passing to the occipital lobes, and the associated fibres uniting different convolutions, they are centrifugal in character. The fibres entering the region of the lenticular nucleus, or between its inner segment and the optic thalamus, have received the name of the *corona radiata*. A relatively small group of fibres passes into the thalamus, which therefore receives centrifugal fibres from the cerebral cortex, and gives origin to the fibres of the tegmentum.

Fig. 112.



Section of the stem of the brain on the level of the posterior part of the optic thalamus; *cn*, caudate nucleus; *th*, thalamus; *pc*, fibres of the posterior commissure; *f*, fillet; *rn*, red nucleus; *cL*, Luys' body; *ic*, internal capsule; *ln*, the lenticular nucleus; *I*, *II*, segments of the same; *p*, fibres of the crusta and of the anterior pyramid; *to*, optic tract; *r*, raphe; *IIIn*, third nerve; *iter*, iter; *pl*, posterior longitudinal fasciculus.

The layer of nerve-fibres lying to the outer side of the lenticular nucleus is called the *external capsule*. The nerve-fibres between the segments of the lenticular nuclei, the nerve-fibres forming the *laminæ medullares* of the thalamus, and the remaining nerve-fibres of the thalamus, including the *bundle of Meynert*, while belonging to the cerebral system, are of unknown significance.

The commissural fibres of the cerebrum embrace those of the corpus callosum, those of the fornix, those of the anterior commissure, the internunciary fasciculi between the areas of the cortex, and the fibres not otherwise identified in the region of the corpus striatum and the optic thalamus. The *fibres of the corpus callosum* unite the cortex of the right and left hemispheres. The *fibres of the fornix*, and the so-called *nerve of Lancisi of the corpus callosum*, unite the central structures of the base of the brain.[1]

The *fibres of the anterior commissure* are arranged in a U-shaped figure, the convexity of the letter answering to the position of the exposed fibres in the third ventricle, and the limbs to the cerebral hemispheres, where they end in the cortex of the temporo-sphenoidal lobes. This commissure further unites the parts of the undifferentiated gray matter lying at the base of the island of Reil, at the base of the claustrum, at the common base of the lenticular and caudate nuclei, and of the olfactory bulb. In the lower animals the anterior commissure is in the main a transverse commissure between the olfactory bulbs. In man a trace only of such a union is detected. The internunciary bundles pass between different cortical areas of the cerebral hemispheres. Some of these bundles unite adjoining convolutions; while others pass from the frontal to the occipital lobe.

The commissural fibres, including the inferior peduncles of the optic thalamus, unite the first segment of the lenticular nucleus with the thalamus, some of the fibres being continuous with the *stratum zonale*. They also serve to unite the nuclei of this region, namely, the red nucleus, the body of Luys, and the ganglion of the habenule.

The stratum zonale is a thin layer of nerve-fibres covering the optic thalamus, and the nerve-fibres themselves are covered at the sides and floor of the third ventricle by the cells of the ependyma. The underlying layer is called the *stratum intermedium*. The entire space between the thalami is often called the subthalmic region (regio subthalmica). The lamina reticularis is a layer lying to the outer side of the thalamus.

The thalamus is reinforced from the pineal gland, through the pineal peduncle of the corresponding side, as well as from the posterior commissure of the third ventricle.

The optic thalamus, from its outer and posterior side, is in connection with numerous fibres from the temporo-sphenoidal and occipital lobes of the cerebrum.

Radiating fasciculi from the optic tract penetrate from below, while others are probably derived from the terminal fibres of the fornix, after circumscribing the mammillary body.

In like manner the olfactory bulb sends fasciculi to the temporo-sphenoidal lobe, where they are in association with the fibres of the occipital lobe, and also join the fibres of the anterior commissure.

[1] The development of the brain shows that the fornix and nerves of Lancisi are evolved from the same portion of the cerebrum, *i. e.*, from the border of the primitive transverse fissure. As already seen, the fibres of the fornix begin in the optic thalamus, and terminate through the fimbriated body in the apex of the temporo-sphenoidal lobe.

The *bloodvessels* of the brain have been considered on pages 370 and 377. The fact may be here noted that the arterioles of the cerebellar supply do not dip between the folia, in this way differing from the arterioles of the cerebral supply which freely enter the cerebral fissures. Vessels separate from those supplying the cortex supply the nucleus of the dentate body. Duret mentions two cases characterized by hemorrhage within the dentate bodies.

Variations.—In the cerebrum the variations are of two kinds, viz: defects of the entire organ; and variations in the disposition of the fissures and convolutions.

The defects of the cerebrum as a whole relate to the imperfect evolution of the hemispheres, and the arrest of development in the commissures. The cerebral vesicles may never pass beyond a simple form. When the hemispheres are imperfectly formed, the division into lateral and third ventricles (see Development) is not effected, and of necessity the corpora striata and the optic thalami are either absent or rudimental. A cerebrum of such a type, with absence of the olfactory bulbs, is found in the cyclops variety of monsters (see section on Teratology). The commissures should always be studied in connection with defects of cerebral development. The free or exposed portions exhibit the most striking defects. Little is known of the minute anatomy of the brain in those examples in which defects of the commissures have been detected.

Defects of the corpus callosum are apt to be associated with defects of the fornix and septum lucidum. In the brain of a child aged eleven months, described by Ward,[1] all the commissures were absent, as well as the transverse fibres of the pons Varolii; the brain falling into two equal halves when it was placed upon the table. Subjects in which the corpus callosum has been found defective have invariably been noted during life for impairment of the mind, although the manifestations of such impairment have been variable. The conclusions of D. N. Knox,[2] respecting the significance of absence of the corpus callosum, are as follows:—

"In those cases in which the commissure-system is wholly wanting, or very rudimentary, idiocy or imbecility prevails. In those cases in which the corpus callosum is only partially defective, while the other commissures are present, intelligence but slightly below the average, together with dulness, levity, melancholy, or perhaps childishness, are the usual mental traits."

In an imperfectly developed brain the corpus callosum may be rudimentary or absent, the fornix without median union, and the middle and posterior commissures absent. The anterior is the most constant of the commissures. The account of the minute anatomy of the brain prepared the reader for these statements, since it was there shown that these commissures have special structural value, because of the dispersion of their fibres through the length of both hemispheres. W. H. Flower,[1] in an elaborate memoir upon the commissures as seen in the brains of the lower animals, has demonstrated that the anterior commissure is the most constant and important in the series. In animals normally without efficient corpora callosa, such as the marsupials and the monotremes, the anterior commissure is relatively large, so as to present a conspicuous appearance upon a sagittal section of the brain.

The variations in the details of the convolutions are numerous. The general plan of such variations has not been agreed upon. Some of the most striking of the variations have been mentioned in the text.

The variations and degrees of asymmetry in both fissures and convolutions are decided, and no constant relation between the right and the left parts is known to exist. But on the whole it may be said that cerebral asymmetry is no more conspicuous than is asymmetry in other structures of the body.

In the temporo-sphenoidal and the occipital lobes, the structure is less compact, and the convolutions are apt to be smaller than in the remaining lobes. The region of the greatest variation is in the occipital lobe, which again is the most remote from the optic thalamus. Numerous unnamed and variable sulci extend upon the vertex from the median surface of each hemisphere.

According to W. H. Flower, many variations in the construction of the posterior part of the occipital lobe must be ascribed to pathological changes. Thus, in aged and debilitated subjects, the posterior cornu is often enlarged and somewhat funnel-shaped, the calcarine process (hippocampus minor) being more or less obliterated, a condition arising from the gravitation of the intraventricular fluid during a long-continued recumbency. In atrophy of the cerebral substance from whatever cause, attended by increased

[1] Lond. Med. Gaz., March 27, 1846.

[2] Glasgow Med. Journ., n. s. vol. vii. 1875, 237.

[1] Phil. Trans. clv., 1865, 333.

size of the ventricular cavity, the change is usually most strikingly seen in the posterior cornu.

In the brains of idiots, according to John Marshall,[1] the most constant among the smaller convolutions are the following: the three frontal convolutions, the supra-marginal, and the angular convolutions, the temporal convolutions on the lateral side of the cerebrum, and the marginal, calloso-marginal, and annectant convolutions, with the quadrate and cuneate lobules on the median side. The most inconstant are the outer orbital and the occipital convolutions. Among other features of the brain of the idiot may be mentioned the reduced size of the island of Reil, the striated body, and the flocculus. The island of Reil is without convolutions, and the striated body is associated with small ventricular cornua. Marshall's figures display a parieto-occiptal fissure, with a long prolongation forward and downward. It is of interest to notice a similar sulcus in the brain of the chimpanzee.

The development and the morphology of the brain.— It is not intended in this place to give an elaborate description of the development of the brain, but rather to indicate those structural peculiarities which, while announced in the fœtus, serve to explain the plan upon which the brain of the adult is constructed.

The brain in its simplest expression is the dilated cephalic extremity of the primitive medullary tube, becomes differentiated into three vesicles, named from before backward, the first, the second, and the third. The first cerebral vesicle answers to the cerebrum of the adult; the second to the corpora quadrigemina; and the third to the medulla oblongata. The first portion is commonly called the *prosencephalon*, and comprises the cerebral hemispheres, internal basal structures, and the olfactory lobes. The second forms the *mesencephalon*, and contains the stem of the brain as far as the pons Varolii, and thus embraces the crura cerebri and the *iter*. The third forms the *metencephalon*, and yields the medulla oblongata, the medullary portion of the fourth ventricle, and the auditory nerve. Between the first and second vesicle, but belonging more especially to the first, lies the *thalamencephalon*. From the roof of this portion of the brain is developed the pineal body, from its floor the pituitary body, and within its walls the optic thalamus and the primitive optic nerve. The roof of the third vesicle forms the *epencephalon;* within it arises the cerebellum, and from its floor arise the pons Varolii and the pontal portion of the fourth ventricle.

[1] Phil. Trans., 1864, 501.

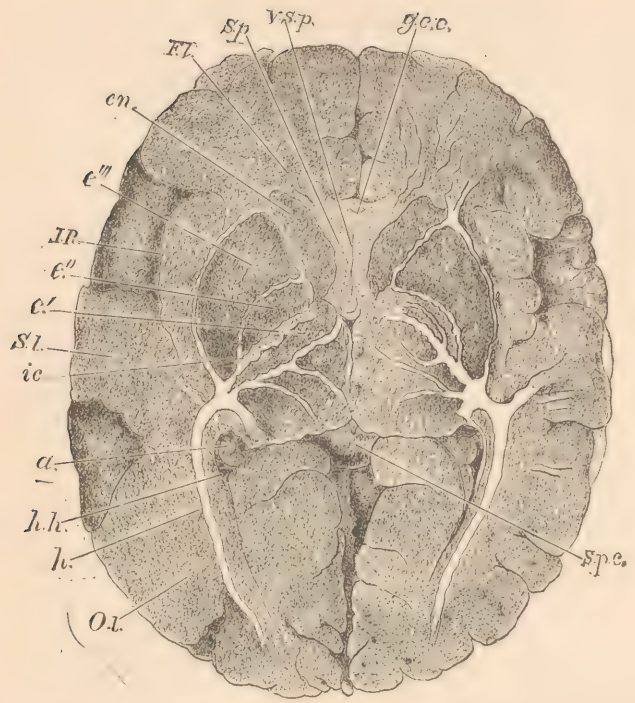
The cerebral vesicles originally are upon the same plane, but subsequently become changed in such wise as to present a basal flexure. As a result of this, the frontal lobe of the cerebrum and the floor of the third ventricle, and the pituitary body lie on the plane of the base of the skull, while the remaining structures of the brain are in the axial line, or nearly so, of the spinal cord. The basal flexure, while most conspicuous at the base, can be detected even in the interior of the brain, namely, at the plane of the posterior cerebral commissure. All the structures lying in advance of the plane of this commissure answer to the anterior part of the brain flexure, and all back of it to the posterior part. The cause of the flexure is commonly attributed to the traction made upon the developing brain by the fixation of the pituitary body through its connections with the base of the skull at a time when the rudimental brain-structures are rapidly expanding. The basal structures at the flexure and in advance of it are of a low degree of specialization,[1] retain many of the features of developing tissue, are of obscure function, and, in the main, are of unknown clinical significance. The basal structures back of the flexure can be assigned to the stem of the brain, to the cerebellum, and to the medulla oblongata. They are of great clinical significance, for within them lie important divisions of the centrifugal and centripetal tracts, and the centres of coördinate movements.

When the parts which are on a higher plane than those of the basal flexure are studied the results are widely different, for here are found high degrees of specialization. The manner in which the uniformly low type of brain structure as seen in the fœtus becomes changed to the highly specialized formations in the adult has been carefully studied by Flechsig, who has found that the development of the brain proceeds *pari passu* with the separation of the central or basal gray matter from the cortical by the appearance of the white or medullary matter between them. In this connection comparisons made between the brain of a child soon after birth (Fig. 113), and a brain of an adult (Fig. 96), will be found valuable.

The parts of the brain yet retained among the imperfectly specialized structures are the corpora striata and the optic thalami. In both these structures the gray matter has a tendency to be separated into

[1] The anterior perforated spaces, which are continuous in front with the caudate and lenticular nuclei, and behind with the amygdalus of the subicular region, the lamina cinerea, the infundibulum, and the pituitary body, are examples of lowly organized structures.

Fig. 113.

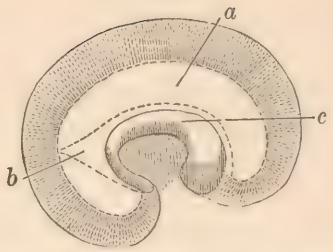


A, horizontal section of the brain of a child aged 32 days, at the level of the posterior cornu of the lateral ventricle; *g c c*, anterior flexure (genu) of the corpus callosum; *s p c*, posterior flexure (splenium) of the corpus callosum; *O l*, occipital lobe; *p h*, posterior horn; *a*, transverse section of hippocampus, i. e., internal capsule; *S l*, spheno-temporal lobe; *e'*, *e''*, *e'''*, segments of the lenticular nucleus; *I R*, island of Reil; *c n*, caudate nucleus; *F l*, frontal lobe; *S p*, septum lucidum; *v s p*, ventricle of the septum (fifth ventricle).

layers by the interposition of white matter, as seen more especially in the white matter between the segments of the lenticular nuclei, and in the laminæ medullares of the optic thalami. Meynert denominates all such attempts at the interposition of layers of white matter the formation of *projection systems*. Thus the white matter between the cerebral cortex and the corpora striata, and the optic thalami is the first projection system; and that between the basal ganglia and the gray matter of the medulla oblongata, the second projection system.

The formation of the first or great projection system causes the cortex to describe a curve a considerable distance from the base, and at least some of the internal structures of the cerebrum to arrange themselves in the form of vertically disposed loops, the ends of which remain fixed at or near the basal encephalic flexure. (Figs. 114, 115.) Thus the caudate nucleus, the fornix, the corpus callosum, and the cerebral hemispheres are so disposed as to form a number of arch-like figures, whose abutments are near one to another at the base of the brain, at or close to the imperfectly differentiated gray matter of the basal flexure.

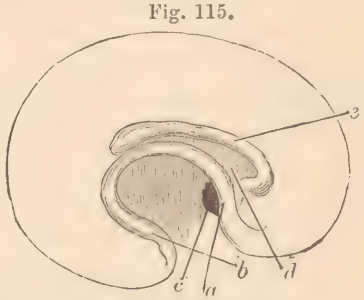
Fig. 114.



a, the primitive space of the lateral ventricle; *b*, the space diagrammatically modified to form the posterior horn of the lateral ventricle; *c*, the caudate nucleus.

The cerebral vesicles are inclosed by gray matter which forms a mass homologous with the central or tubular gray substance of the spinal cord, and which,

Fig. 115.



e, the corpus callosum; *d*, the septum lucidum; *a*, *b*, the fornix; *c*, the foramen of Monro.

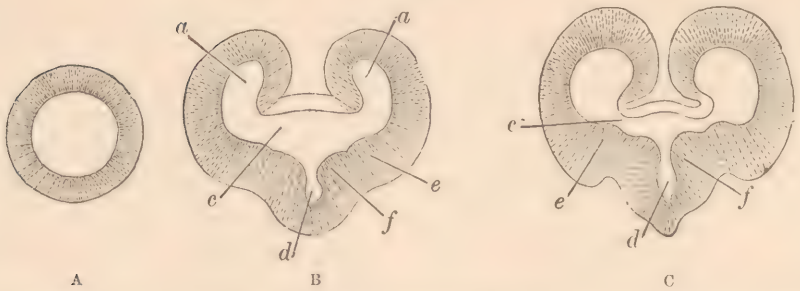
as already seen, can be traced up in the brain as far as the plane of the encephalic flexure. Beyond this place it can be but imperfectly discerned, if at all.

The vesicles are at first tubular, and, with the exception of the third, which is in part exposed to form the medullary portion of the floor of the fourth ventricle, they remain inclosed. The first vesicle soon becomes indented on the dorsal surface to form the great longitudinal fissure. (Fig. 116.) This is an important feature of the developing brain, for it is the first exhibition of the bilateral plan upon which this organ is constructed. Resulting from the presence of this depression, the tubular form of the vesicle is changed to a tripartite one, which presents on frontal (transverse) section the form of a trefoil, of which figure the lateral lobes limit the lateral ventricle, the median lobe (now basal), the third ventricle. The lumen of the ventricle last named is narrowed by the thickening of its sides, and the entrance into the lateral compartments effected by a single opening (called in human anatomy the foramen of Monro), which in the adult becomes narrowed and obscure.

In addition to the above data and reflections, the following facts may prove useful:—

The form of the surface of the adult cerebrum is determined in great part by the constancy of certain

Fig. 116.



A, a frontal section of the first cerebral vesicle before modification; B, the same, after formation of great longitudinal fissure; C, the same, after completion of the formation of the ventricles; *a*, lateral ventricle; *c*, foramen of Monro; *d*, third ventricle; *e*, corpus striatum; *f*, optic thalamus.

basal structures. The most important of these are the striated body, the optic thalamus, and the olfactory tract.—*The striated body.* The sagittal (antero-posterior) section of the brain shows upon the median surface that the frontal convolutions have a tendency to pass concentrically over the striated body from below upward. This structure, lying as it does upon the base of the brain (as seen at the anterior perforated space), permits the convolutions to pass in front and above only. The frontal lobes are firmly braced by the transverse fibres of the anterior commissure, and by the genu and rostrum of the corpus callosum, and are strengthened from before backward by the longitudinal fibres of the same, together with the olfactory fibres, extending to the temporo-sphenoidal and the occipital lobes. It follows from these considerations that the frontal lobe, and also the parietal, since the latter is a posterior and superior extension of the former, are compact and relatively constant in their superficial features.—*The optic thalamus.* The sagittal (antero-posterior) section of the brain shows upon the median surface that the cerebrum has a tendency to turn over the optic thalamus from above downward, and to determine the form of the temporo-sphenoidal lobe. This latter structure holds the same relation to the occipital as the parietal does to the frontal lobe. Sulci freely pass from one to the other, and they have much in common in their plan of organization. In harmony with the concentric curvature of the temporo-sphenoidal lobe around the optic thalamus is the position of the fornix, of the dentate convolution, and of the hippocampal sulcus. The extension of the occipital lobe backward from the temporo-sphenoidal lobe determines the positions of the calcarine and parieto-occipital fissures.—*The tract of the olfactory nerve.* This tract creates the position of the straight sulcus. The great importance of the internal relations of the tract has been already mentioned.

The frontal and parietal lobes possess throughout well-defined and for the most part constant convolutions. The olfactory sulcus, for example, is fixed, as well as the frontal convolutions, particularly as they define the region of the fissure of Sylvius. The region of the greatest variation lies to the outer side of the olfactory sulcus, and the farthest away from the control of the striated body. These lobes are moreover without any fissures answering to central structures, while median sulci, *i. e.*, those extending upon the vertex from the median surface, are few and inconspicuous.

The Bilaterality of the Brain.—As in the spinal cord, so in the brain, many of the structures are paired. Among those which are not paired may be mentioned the pineal body, the pituitary body, the posterior perforated space, the lamina cinerea, the valve of Vieussens, and the infundibulum.

The disposition of nerve-cells, which are on one side of the median line, to dominate muscles and sentient surfaces on the other, is in the following instances explained upon anatomical grounds.

The tracts of the crusta and the anterior pyramids decussate at the anterior pyramids; the tegmental tracts decussate in the medulla oblongata; the cerebral hemispheres are held together by the numerous decussating bands in the transverse commissures. The intrinsic fibres of the fourth nerves decussate, as is also the case with the optic nerves; the fibres from the main olivary body decussate to pass to the cerebellar hemisphere of the opposite side; the two main olivary bodies freely intercommunicate by means of the intermediary system of Flechsig.

The Weight of the Brain.—The weight of the adult European brain, according to Prof. Turner,[1] is in the male from 49 to 50 ounces, and in the female from 44 to 45 ounces.

[1] Introduction to Human Anatomy, 1867, 296.

A brain-weight of less than 30 ounces is always accompanied by idiocy.

The recorded weights of some of the more remarkable brains among eminent men are as follows:—

	Ounces.		Ounces.
Cuvier,	64½.	Spurzheim,	55.
Abercrombie,	63.	Sir Jas. Y. Simpson,	54.
Dupuytren,	62½.	Agassiz,	53.4.
Goodsir,	57½.	Daniel Webster,	53.5.

In epileptics and demented persons large and heavy brains, ranging from 60 to 64 ounces, have often been found; while the heaviest brain on record (67 ounces) was that of a common laborer who never showed any evidence of more than average mental power.[1]

Remarks on the Brain.—A practical study of localized disease in the brain may be made by investigating the effects of interference with the nutrition of either the nerve-cells or the nerve-fibres at a particular place. Thus in the medulla oblongata two distinct groups of lesions may be discriminated: those pertaining to the nerve-centres, and the nerves in connection with them at the floor of the fourth ventricle; and those pertaining to the strands of nerve-fibres that are in transit through the medulla. Much of the clinical value pertaining to these divisions of the brain will depend upon the application of a knowledge of the minute anatomy of the part to the case or condition presented. To a greater extent than is seen in the spinal cord, morbid changes in the brain are related to processes of degeneration or gross lesion occurring in the nerve-tissue about the bloodvessels.

In the description in the text, the attempt is made to consider the brain as a single organ, as far as it is possible so to do, and to treat of this organ as composed of variously arranged groups or layers of nerve-cells connected by bundles of nerve-fibres, and the whole placed in communication with other structures of the economy. A similar attempt will be made in this place to apply the facts of the anatomy of the brain, as thus defined, to practical medicine; for, clinically as well as morphologically treated, the brain is an aggregation of functionally related ganglia which hold intimate relations not only one to another, but to the gray matter of the spinal cord and to the peripheral nerve-trunks as well. In addition the brain may be considered as being composed of the medulla oblongata; the cerebellum; the structures composing the stem of the brain (viz., the pons Varolii, the crura cerebri, and the corpora quadrigemina as related structures); and the pituitary body.

The brain considered as a single organ.—Since Waller (see p. 462) discovered that the nutrition of the peripheral nerves is controlled by certain nerve-cells placed in connection with the nerve-fibres, it has been of interest to ascertain to what extent a similar control would be found to exist in the central nervous system. Among the great number of bundles of nerve-fibres in the brain but two have so far been known to pass into degeneration after destruction of the connection between them and the nerve-cells thus associated with them. These tracts are the pyramidal tract, and the tract of the fillet.

The pyramidal tract.—This is a name given, as has already been seen, to those fibres of the brain which form in part the median portion of the internal capsule. These fibres are continuous in the spinal cord with the antero-median and postero-lateral tracts. In the brain above the medulla they pass from the motor region of the cerebral cortex to the internal capsule, thence through the crusta, and thence through the pons to the medulla oblongata.

Secondary degeneration, according to Charcot,[1] is generally most evident on the middle two-fourths of the inferior surface of the cerebral peduncle.

The tract of the fillet.—This tract is described by Meyer,[2] who detects degenerative processes confined to it extending centrifugally as far as the level of the fibres of decussation of the pyramid. E. C. Spitzka is disposed to attribute the prominence of the symptoms referable to disturbances of vision, especially the diplopia and amblyopia of the first stages of acute inflammation of the spinal cord, to a continuity which exists, by means of the fillet, between the lateral columns of the cord and the anterior pair of the corpora quadrigemina. The same observer assigns some form of atrophy of the optic nerve to a spinal origin.

Other tracts can also be determined by defective development; for instance, when the fibres of the pons Varolii, of the corpus callosum, of the fornix, etc., are found to be dependent upon the development of the nerve-cells of the parts united by these commissures.

The brain considered topographically, and, in this sense, as divided into the medulla oblongata, the cerebellum, the stem of the brain (crura cerebri, corpora quadrigemina, and related parts), and the pituitary body.[3]

[1] Jas. Morris, British Medical Journal, 1872, 465.—For elaborate accounts of the weight of the brain, see G. Schwalbe, Lehrbuch der Neurologie, 589; also, Quain's Anatomy, ii. 380.

[1] Le Progrès Médical, 1879, 557.

[2] Archiv für Psychiatrie, 1882, xiii, 63.

[3] Care has been taken to omit all *negative results of observations.*

The Medulla Oblongata.[1]—In the gray matter of the medulla oblongata are located the centres controlling important correlations. Any considerable lesion or pressure against the floor of the fourth ventricle will cause death. Cases in which hemorrhage occurs in the third ventricle will often terminate fatally by the blood flowing through the iter to the fourth ventricle.

Hemorrhage into the medulla oblongata without involvement of the pons is rare. Jodin[2] reports a typical example of the lesion: A woman, sixty-four years of age, while in a fit of passion, suddenly fell dead. The fourth ventricle and the pia mater were found hyperæmic, and a clot the size of a hickory-nut lay in the gray matter at the upper part of the medulla. The olivary nuclei were destroyed, but the pyramids were intact. In a case reported by Waters[3] an extravasation of blood occurred in the substance of the medulla posteriorly and to the right side. In other instances the lesion has been known to involve the entire length of the medulla. Blachez[4] describes a lesion of the medulla in which blood escaped from the basilar artery at its middle third, lacerating the medulla and entering the fourth ventricle, but not lacerating the pons.

Medullary lesion may be the result of diseased action indirectly excited by the position of bloodvessels. The lesion may be, in part at least, peripheral, or it may be entirely concealed so as not to be apparent without careful microscopical study of the medulla. Cases have been recorded of extensive degeneration of the anterior pyramid, the olivary nucleus, the raphe, the region of the hypoglossal nuclei, the restiform body, and the gelatinous substance.

In a case reported by A. T. H. Waters,[5] a blow on the face was followed by dilated pupils and nystagmus. After death a blood-clot was found in the right restiform body and on the floor of the fourth ventricle. In a case observed by E. Baelz[6] in a woman of fifty-five years, acute facial neuralgia, contraction of the tongue and lips, aphagia, loss of speech, followed later in the case by paralysis of the oral fibres of the seventh nerve, and of the entire region of distribution of both twelfth nerves, were the symptoms associated with fibro-sarcomatous tumor arising from the base of the cerebellar fossa and pressing against the medulla oblongata and the pons Varolii.—The site of the olivary body may be occupied by a clot of blood, as was found by Meyer.[1]

The Cerebellum.—In a remarkable case reported by M. Combette,[2] the cerebellum, the pons Varolii, and the fourth ventricle were absent, their positions being occupied by membrane and by serum. The anterior pyramids could be traced directly into the crura cerebri.

The cerebellum when atrophied is concealed by the occipital lobe of the cerebrum. The hemispheres are the portions which sustain the greatest loss. In a case reported by G. Seppilli,[3] the organ weighed a little less than half the normal weight. The gray substance was reduced in size, and the dentate body thinned, while the medullary substance was contracted. The hemispheres may be reduced to the size of almonds. Either one or both hemispheres may be involved. Atrophy of the pons is of necessity involved in marked atrophy of the cerebellar hemispheres.

It is thought that atrophy of the cerebellar hemisphere of one side is always associated with atrophy of the olivary body of the opposite side.

The phenomena of cerebellar atrophy are exhibited in weak muscular power of the muscles of the trunk and limbs, as well as in impaired power of co-ordinating muscular actions. A disposition to epileptic seizure exists. The mental power is often impaired.

With imperfect development of the cerebellum, atrophy of the anterior peduncle (prepedunculus) has been found associated; and, on the other hand, a common stump of the three peduncles has been found on one side, the corresponding hemispheres being absent. In loss of the right hemisphere, atrophy of the right olivary body and atrophy of the right corpus striatum have been found associated.

It is interesting to note that the portions of the cerebellum that are most liable to atrophy appear the last in the order of evolution of the cerebellum, and that the median structures which are constantly present in the cerebellum of all air-breathing vertebrates are not liable to atrophic changes. In a word the portions which are most plastic in a morphological sense are also those which yield most readily.

Rarely the cerebellum may be pressed upon by a dermoid cyst. Heimpel reports a case in which the

[1] As an aid in localizing the effect of diseased action, the reader should consult the figures in the description of the minute anatomy of the brain, and the directions for securing planes of fixed value.

[2] Gaz. de Hôpital, t. vii.

[3] Infra.

[4] Bull. de la Soc. Anat., t. 37, 1862, 335.

[5] Med.-Chir. Trans. xlvi. 1863, 115, 199, fig. Archiv für Heilkunde, 1872, xiii. 199, fig.

[1] Arch. f. Psychiatrie, 1880, xiii. 63.

[2] Journ. de Physiologie exper. et pathol. (Magendie), xi. 1831, 27, figs.

[3] La Revista Sperimentale di Freniatria e Medecina Legale, 1879, Tas. iv. Trans. by J. Workman, The Alienist and Neurologist, i. 1880, 405.

inferior vermis was thus obliterated.—Hemorrhage may occur both in the cortex of the cerebellum and in the dentate body.—The lesions of the cerebellum, such as may arise from a tumor, or from degenerative effects in proximity to a blood clot, are apt to be associated with phenomena of forced movements, with reeling gait and feeble coördination, with vertigo, and not unfrequently with epileptiform seizures. A clot of blood lying at a point in the peduncular system of the cerebellum where the right anterior and the posterior peduncles meet may be associated with a marked disposition to flexion of the limbs, retraction to the right side, and bowing of the head. Paralysis of the third nerve and optic neuritis may co-exist. The existence of paralysis of one or more cranial nerves, particularly the seventh and the twelfth, in cerebellar lesion, is in all probability to be attributed to pressure-effects (see Arachnoid). H. Nothnagel[1] found no definite symptoms associated with disease of an entire hemisphere, but reeling gait was found in connection with disease of the superior vermiform process. Muscular rigidity, and, in the latter stages of the disease, paraplegia may supervene.[2]

Lesions of the Stem of the Brain. The pons Varolii may be pressed upon by an exostosis arising from the posterior clinoid process of the sphenoid bone. In a case of this kind, reported by Belhomme, the patient had been subject to attacks of vertigo and impairment of the motions of the legs, followed by forced movements from right to left. Toward the close of the case convulsions with rotatory movements from left to right ensued.

Gueniot[3] reports a case in which a blood-clot, the size of an almond, occupied the pons Varolii in such a manner as to correspond to the floor of the fourth ventricle, which, however, was not destroyed, and to the superficial transverse fibres of the pons, which were destroyed in part. This case is chiefly noteworthy from the circumstance that the raphe had in a measure resisted the pressure of the mass and had served to divide the clot into a large right and a small left portion. Hemiplegia of the left side, paralysis of the twelfth nerve, and loss of speech occurred. Death ensued at the end of four days.

Many cases are on record of lesion of this portion of the brain where crossed hemiplegia was the most conspicuous symptom. In all likelihood, in these cases the lesion involved the tract of the crusta and the anterior pyramid. Hemorrhage is not of infrequent occurrence in the pons. It is apt to involve the medulla and to prove rapidly fatal. It would appear that owing to its firmer consistence the fibres of the pons will resist for an appreciable interval the distending force of blood escaping into it; when, however, the fibres yield, it is in the direction of the medulla, and a gross lesion occurs therein which proves suddenly fatal. It will be thus seen that blood escaping into the fourth ventricle as well as blood escaping into the pons may cause death by subsequent pressure within the medulla oblongata.

The Corpora Quadrigemina. The anterior pair of the tubercles control vision. H. C. Bastian[1] recognized after death a patch of softening in the anterior pair which had caused blindness. A sarcomatous growth originating in the pineal body has been known to invade the corpora quadrigemina, as one originating in the corpora quadrigemina may destroy the pineal body. A. B. Duffin[2] describes an example of gliomatous tumor which occupied the site of the corpora quadrigemina and the pineal gland and extended thence forward to invade the third ventricle, as well as backward along the iter to involve the fourth ventricle. The patient had exhibited vertigo, tinnitus, deafness, vomiting, irregular pulse movement, and toward the end of the case delirium and coma. The optic disks were infiltrated with products of inflammation.

Peltzer[2] reports a case in which an embolism of the basilar artery was found associated with a symmetrical patch of softening in the posterior outer third of the thalamus, causing softening of the side of the corpora quadrigemina and in both occipital lobes.

The Pineal Body. Carl Wiegert[3] gives the details of an extraordinary congenital tumor of this body containing structures resembling those of an ovarian dermoid cyst, such as sebaceous matter and hair-follicles and hairs, and also cartilage, fat, cylindrical epithelial cells, and unstriped muscular fibre. An interesting feature in this specimen was the relation it bore to the quadrigeminal mass. Since the pineal body lies over the quadrigeminal mass, a growth within the former would apparently press downward upon the latter. But in the case quoted it was directed forward and downward in the third ventricle, exerted pressure upon the thalami upon their median aspects, and, gaining a lower plane than its origin,

[1] Berlin. klin. Wochensch., 1878, No. 15; also, Topog. Diagnose der Gehirnkrank. 4.

[2] See J. Dreschfeld, Journ. of Anat. and Phys., 1880, xiv. 340, for well reported case and literature.

[3] Bull. de la Soc. Anat. 1860, 321.

[1] Lancet, July, 1874, 112.

[2] Ibid., 1876, ii. 77.

[3] Virchow's Archiv, 1875, 212. (Fig.)

extended backward and actually raised the quadrigeminal mass from beneath.

W. R. Gowers[1] describes a case in which the pineal body was absent, and its place taken by a sarcomatous tumor. A pedunculated growth extended from the tumor upward above the tentorium.

The Cerebrum.—The clinical remarks that can with propriety be made upon the anatomy of the cerebrum, that have not already been embraced in the general remarks on the brain as a whole, are but few in number. They relate to the effects of irritation, of gross lesion, and of diseased action.

The effects of irritation of the cortex of the brain vary remarkably in different areas. The extreme tip of the frontal lobe may be pressed upon by a tumor, or destroyed by fracture or by a foreign body, without cerebral disturbance. The same remark is, in a measure, applicable to the occipital lobe, although within this region blindness and loss of the sense of smell may follow from similar causes. After lesion of the convolutions bordering upon the fissure of Rolando, namely, the ascending frontal, the ascending parietal, the posterior central, the supra-marginal, distinct errors of muscular coördination ensue. Sciamanna[2] found, as the result of stimulating these parts, as they were exposed in a defect of the cranial vault, that the excitation of the ascending frontal convolution at its middle produced contractions of the Masseter muscles, that similar excitation of the ascending parietal convolution was followed by contraction of the Dilator Nasi and the muscles raising the angle of the mouth. In like manner excitation of the cortex at a point between the ascending parietal and inferior parietal lobes produced flexion of the arms and raising of the eyebrow; and of the supra-marginal convolution rotation of head from the right to the left, and movements of the Orbicularis Palpebrarum. The region thus outlined by Sciamanna, including the paracentral lobes on the brain subject, answers to the one previously known to exist as the result of experimentation on animals, and may be known as the *motor zone*. J. Hughlings Jackson found that in epilepsy voluntary and independent movements are first to suffer from any cause affecting the centres of this zone.—Attempts have been made, but with little success, to identify the excitation of the occipital lobes with errors of sensation.

Of the different portions of the cortex whose function is determined is the one known as the *region of Broca*, which lies at the base of the left third frontal convolution. Injury to this region produces the condition known as aphasia, by which term is meant the imperfect coördination between mental processes and the mechanism of speech. From the fact that aphasia is commonly induced either directly or indirectly by pressure against this region, its existence is of value in connection with the study of hemiplegia. The convolutions of the island of Reil may be obliterated, and the entire surface raised, though rarely ruptured, by a clot of blood involving the cortex. The pressure in this way exerted against the region of Broca is the common cause of the symptoms enumerated.

The topography of the cerebrum in the region of the striated body and the optic thalamus is of great practical importance. In a general way it may be said that the anterior portion of the internal capsule at its anterior two-thirds, the anterior extremity of the caudate nucleus, and the anterior two-thirds of the lenticular nucleus make up the *lenticulo-striated region*. In like manner the posterior portion of the internal capsule, namely, that between the lenticular nucleus and the optic thalamus, composes the *lenticulothalamic region*. Lesions of these regions can be studied as situated in the internal capsule, the external capsule, and the several nuclear masses, *i. e.*, the lenticular nucleus, the caudate nucleus, optic thalamus, and the claustrum. Hemorrhage may originate or be restricted to any of these, or may involve, by secondary changes, adjacent regions. According to Charcot,[1] if hemorrhage involves the outer capsule only, the patient may recover, and in all probability without the persistence of hemiplegia, notwithstanding the extent of the lesion; if, on the other hand, hemorrhage involves the inner capsule, persistent paralysis remains in the event of the patient surviving.

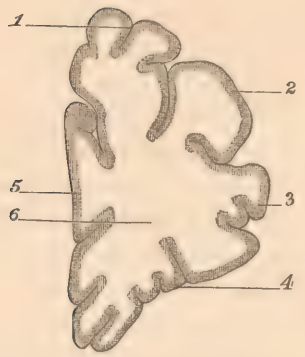
Isolated lesions of the caudate and lenticular nuclei are of less grave import than are those affecting the internal capsule. Lesions in the lenticulo-striate region resemble those of the anterior portion of the internal capsule, and are followed by paralysis of the limbs of the side of the body opposite to the lesion. Lesions in the lenticulo-thalamic region, in addition to the symptoms of the lesion of the lenticulo-striate region and the anterior portions of the internal capsule, induce hemianæsthesia, and impair the integrity of the functions of the special senses, notably those of vision and olfaction.

Owing to the relation existing between the frontal and temporo-sphenoidal lobes and the base of the skull, as compared with those structures embraced in the pos-

[1] Lancet, 1879, i. 365. [2] Arch. di Psychiatria, 1882, 209.

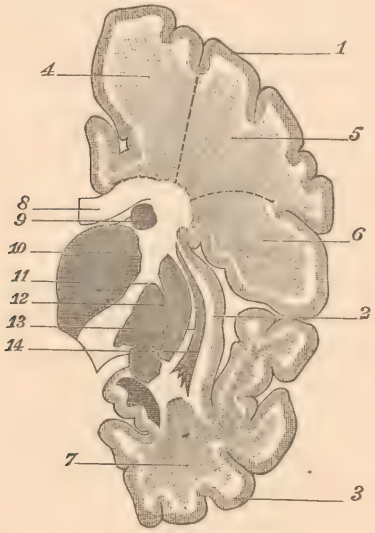
[1] Leçons sur les Localis. dans les Mal. du Cerveau, 1876, 8.

Fig. 117.



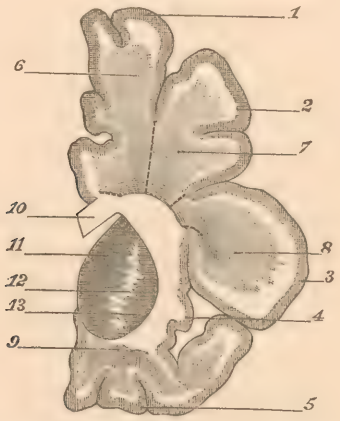
The præ-frontal plane. 1, first frontal convolution; 2, second frontal convolution; 3, third frontal convolution; 4 orbital convolutions; 5, convolutions on the internal aspect of the frontal lobe; 6, præ-frontal fasciculi of the centrum ovale.

Fig. 118.



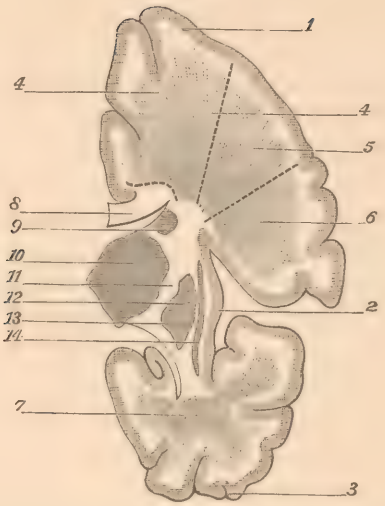
The frontal plane. 1, ascending frontal convolution; 2, lobule of the Island of Reil (insular lobule); 3. sphenoidal lobule; 4, 5, 6, superior, middle, and inferior frontal fasciculi; 7, sphenoidal fasciculus; 8, corpus callosum; 9, caudate nucleus; 10, optic thalamus; 11, internal capsule; 12, lenticular nucleus; 13, external capsule; 14, claustrum.

Fig. 119.



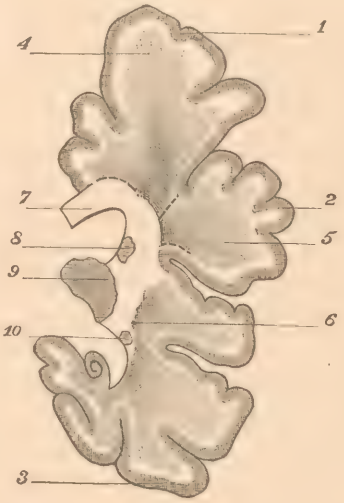
The pediculo-frontal plane. 1, 2, 3, first, second, and third frontal convolutions; 4, anterior extremity of the Island of Reil; 5, posterior extremity of the orbital convolutions; 6, superior pediculo-frontal fasciculus; 7, middle pediculo-frontal fasciculus; 8, inferior pediculo-frontal fasciculus; 9, orbital fasciculus; 10, corpus callosum; 11, caudate nucleus; 12, internal capsule; 13, lenticular nucleus.

Fig. 120.



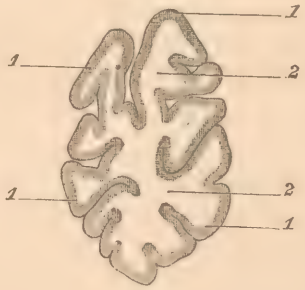
The parietal plane. 1, ascending parietal convolution; 2, Island of Reil; 3, sphenoidal lobe; 4, superior parietal fasciculus; 5, middle parietal fasciculus; 6, inferior parietal fasciculus; 7, sphenoidal fasciculus; 8, inferior pediculo-frontal fasciculus; 9, orbital fasciculus; 10, corpus callosum; 11, caudate nucleus; 12, internal capsule; 13, lenticular nucleus; 14.

Fig. 121.



The pediculo-parietal plane. 1, superior parietal lobule; 2, inferior parietal lobule; 3, sphenoidal lobe; 4, superior pediculo-parietal fasciculus; 5, inferior pediculo-parietal fasciculus; 6, sphenoidal fasciculus; 7, corpus callosum; 8, and 10, caudate nucleus; 9, optic thalamus.

Fig. 122.



The occipital plane. 1, occipital convolutions; 2, occipital fasciculi of the centrum ovale.

terior occipital fossa, it has been found that the contusion of the lobes first named, due to falls upon the skull, or to other injuries, is relatively greater than in injuries to the occipital lobe, or to the stem of the brain or to the medulla oblongata.

Lesions from external injury, such as follow upon bruising and sloughing of the cerebrum, may determine the escape of the fluid of the lateral ventricles through the external wound. Prescott G. Hewett believes this to have been the case in two examples of such lesion detailed by him.[1] In one of these a dissection of the parts involved showed that the minute opening through which the fluid had escaped led directly to the lateral ventricles. The amount lost in the course of the effects of the injury may be very great, and would appear to be due to the continuity of the lateral ventricles with the vertebral canal. In contusions of the cerebrum the under part is very much more frequently bruised than any other, and the evidences of such contusion may extend over the whole surface of a lobe, and oftentimes of two lobes. Both gray and white substance may be extensively involved. The lateral ventricles at the anterior cerebral lobes may in this way be exposed.

As an aid to the practitioner in locating the effects of diseased action in the cerebrum, the figures on p. 508 exhibiting a number of frontal (transverse) sections of the cerebrum are herewith introduced. They are known as the planes of Pitres[2] from the observer who introduced them. These planes are as follows: the prefrontal, the frontal, the pediculo-frontal, the parietal, the pediculo-parietal, and the occipital.

The Pituitary Body.—The only structure on the base of the brain which may be considered separately from other portions is the pituitary body. The anterior portion of the body is the occasional site of cystic growths which may absorb in great measure the body of the sphenoid bone, and by pressing upward encroach upon the third and the lateral ventricles. C. Wiegert[3] describes a gummatous tumor of the anterior portion of the pituitary body. It extended from along the entire base of the middle cerebral fossa, and pressed against the structures entering the left orbit, and embraced the left carotid artery. Two cases have been recorded[4] in which hypertrophy of the pituitary body was found associated with general hypertrophy. The connection between the two conditions is certainly obscure.

[1] Holmes's System of Surgery, ed. 1861, ii. 140.

[2] Lésions du Centre Ovale, Paris, 1877.

[3] Virchow's Archiv, 1875, 219. See also Zenker, Ibid., xii. 454.

[4] H. Henriot, Union Med. et Sci. du Nord-Est, 1877, and D. J. Cunningham, Journ. of Anat. and Phys., xiii. 1879, 508.

The Membranes of the Brain.

The membranes of the brain are—

The Dura Mater.
The Pia Mater.
The Arachnoid Membrane.

THE DURA MATER.

The Dura Mater (fig. 2, Plate LXXII.) is a firm fibrous membrane investing the brain, outside the pia mater and arachnoid, and, at the same time, lining the skull.

It is loosely attached to the skull above, being united to the lines of the sutures. Minute bloodvessels and delicate trabeculæ pass from it into the diploë. It is firmly attached to the base of the skull, where it not only closely conforms to the configuration of the cerebral fossæ, but sends a layer across the top of the pituitary fossa, embracing the infundibulum and concealing the pituitary body. It also secures especially strong attachments to the edges of the foramina, the crista galli, the petrosal ridges, and to a line extending thence to the *dorsum sellæ*. The dura mater is everywhere smooth on its inner surface, where it is lined with pavement epithelium. The outer surface is pilose, as is seen when it is floated in water. The space between the dura mater and the arachnoid membrane is called the *subdural space*.

The dura mater exhibits at certain points a tendency to split into two layers. The spaces between the layers are called *sinuses*, and contain venous blood. The sinuses are lined with endothelium similar to that found in the veins. The inner of the two layers is projected inward so as to form three prominent membranous septa, which have received the names of—

The Great Longitudinal Falx.
The Lesser Longitudinal Falx.
The Tentorium.

The Great Longitudinal Falx (the cerebral falx) lies in the great longitudinal fissure of the brain. It is narrow anteriorly where it is attached to the crista galli, but becomes wider posteriorly, and finally terminates at the region of the internal occipital protuberance. Its posterior border is fixed and convex, and defines the great longitudinal sinus; its anterior border is free and concave, and accommodates the lesser longitudinal sinus.

The Lesser Longitudinal Falx (the cerebral falx) lies in the median line between the tentorium and the foramen magnum. Its lower border tends to bifurcate. This falx is small, occupies the posterior notch of the cerebellum, and possesses, as a rule, a small sinus at its base.

The Tentorium extends transversely across the cranial cavity between the great longitudinal and the lesser longitudinal falx at the position of the transverse fissure of the brain. The posterior lobe of the cerebrum lies upon the tentorium, while the cerebellum lies below it. It is convex above, and concave below. The lateral sinuses are lodged between the two layers of its base, which are separated for their accommodation at the attachment of the tentorium to the transverse ridges of the occipital bone.

The dura mater contains lymph-spaces within its meshes, and minute branches of cranial nerves, notably of the twelfth, and ophthalmic branches of the fifth.

Remarks.—The tributaries of the longitudinal sinus are often occluded in inflammatory affections of the sinus. The dura mater may become thickened and adherent to the skullcap, especially at points corresponding to the sutures. The membrane may be the site of encephaloid cancer, which has been specially noted as occurring near the foramen magnum. A tumor so situated may evoke symptoms resembling those attending upon lesion of the medulla oblongata.[1]

Tumors may also occur at the region of the temple along the course of the great meningeal artery.[2]

The violent headache which so commonly accompanies hemorrhage, and the other causes of suddenly induced encranial disturbance, may be attributed to distension of the dura mater and to pressure against the sensory nerves distributed to it. For additional remarks, see p. 511.

THE PIA MATER.

The Pia Mater is a delicate fibrous membrane of great vascularity, which lies beneath the arachnoid, and invests the brain and the spinal cord. The pia mater of the brain is composed of two layers: an outer layer, which is well defined and accommodates the larger vessels; and an inner layer (flocculent layer), which is continuous with the neuroglia, and accommodates in part the small twigs which penetrate the brain. From these arterial twigs arise a number of minute branches, which pass at varying distances into the brain-substance. The pia mater fills in not only the sulci of the cerebrum and the cerebellum, but the larger interspaces of the external aspect of the brain. Among these interspaces may be mentioned the great longitudinal fissures, the superior and inferior transverse fissures, and the chink-like passage by which the superior transverse fissure passes into the descending horn of the lateral ventricle, at the outer side of the crura cerebri. The adaptation of the parts last named is sufficiently exact to prevent the escape of the ventricular lymph, even under circumstances of great pressure.

The subdivisions of the pia mater, as they pass within the fissures and lie within the ventricles, have received separate names as follows:—

The Velum Interpositum.
The Superior Choroid Plexus.
The Choroid Plexus of the Third Ventricle.
The Inferior Choroid Plexus.

The Velum Interpositum is the largest subdivision of the pia mater. It is formed by this membrane as it passes through the superior transverse fissure into the third and lateral ventricles. The velum is triangular in form, its base corresponding to the transverse fissure, and its apex to the foramen of Monro. It lies beneath the fornix, incloses in part the pineal gland, and overlies the corpora quadrigemina. It contains two ventricular veins which are tributary to the straight vein of Galen.

The Superior Choroid Plexuses (the larger choroid plexuses) are continuous with the lateral borders of the velum interpositum. Each plexus lies within the lateral ventricle of its own side, unites in front through the foramen of Monro, with its companion of the opposite side, but diverges behind to extend nearly the entire length of the floor of the descending horn. Each is a fusiform mass of bloodvessels arranged in loops of various sizes, held together by connective tissue, and enveloped in a well-defined layer of pavement epithelium. Not infrequently minute cystic growths (so-called hydatids) are seen upon this plexus, while granules resembling the acervuli of the pineal gland are sparsely distributed throughout its substance.

The Choroid Plexus of the Third Ventricle. This is formed by two small vascular outgrowths which arise from the under surface of the *velum interpositum*, and project into the third ventricle.

The Inferior Choroid Plexus (the smaller choroid plexus) lies over the medullary half of the floor of the fourth ventricle. The vessels are arranged in two

[1] W. Ogle. Trans. Path. Soc. London, 1853, 3.
[2] Doane's Blandin, 45.

lateral sets and a median set. The *lateral set* on each side occupies the lateral angle of the fourth ventricle, and projects in the subarachnoid space between the flocculus and the roots of the glossopharyngeal and the pneumogastric nerves. The *median set* is composed of two longitudinally disposed tufts which extend forward from the foramen of Majendie along the under surface of the inferior vermiform process to the transverse line uniting the lateral sets. For the manner in which these structures assist in forming the roof of the fourth ventricle, see p. 474.

The nerves of the pia mater are derived from the sympathetic system, as well as from the third, sixth, seventh, eighth, and eleventh cranial nerves.

The membrane possesses a few lymphatic vessels, and is rich in perivascular spaces, which accompany the sulcal processes.

The bloodvessels of the pia mater are derived from the internal carotid and vertebral arteries.

Remarks.—The pia mater being the membrane in most intimate association with the encranial bloodvessels, its clinical bearings are much the same as those of the vessels themselves. The changes in the connective tissue about the bloodvessels are of great importance in determining the initial stages of many morbid processes. The pia mater, dura mater, and arachnoid membrane are often found adhering to one another, and to the skull.

THE ARACHNOID MEMBRANE AND THE LYMPH-SPACES OF THE BRAIN-CASE.

The Arachnoid Membrane is a name given to a delicate, fibrous, non-vascular membrane lying between the dura mater and the pia mater.

The arachnoid is continuous with the membrane of the same name in the vertebral canal, and the two aid in the bounding of the great lymph spaces of the central nervous system.

The arachnoid membrane bridges over the cerebral and cerebellar sulci, extends across the base of the inferior transverse fissure, forms a compartment for the basilar artery (thus dividing the pontal region into a median and two lateral portions), extends thence to the optic chiasm, and the lamina cinerea, bridges over the basal aspect of the fissure of Sylvius, and finally follows the exposed portion of the corpus callosum through its entire length. It in addition provides sheaths for the lymph-spaces of the vessels of the brain, and for the cranial nerves as they escape from the cranium.

The space between the dura mater and the arachnoid is called the *subdural lymph-space*. The space between the arachnoid and the pia mater is called the *subarachnoid space*. The subdural space is lined with endothelium, and is a space somewhat resembling the pleural or the peritoneal sac. The subarachnoid space is crossed by numerous fibrous bands, which, from their number and delicacy, resemble the fibres of a spider's web. The interstices between the fibres are occupied by lymph. The subarachnoid space is best developed at the base of the brain, where it forms a number of lacunæ (cisternæ). The *central lacuna* is found at the position of the body of the sphenoid bone, and the beginnings of the two fissures of Sylvius. It is continuous thence with a narrow lymph-space, which extends along the line of the fissure of Rolando through its entire length. The *lacuna of the corpus callosum* follows the anterior flexure of the corpus callosum, and covers the exposed portions of this commissure at the base of the great longitudinal fissure. The lacuna of the *superior transverse fissure* and that of the *inferior transverse fissure* occupy respectively the fissures after which they are named. A well-defined lacuna in addition lies at the sides of the pons Varolii on either side of the basilar artery. The subarachnoid space communicates with the lymph-spaces of the nasal mucous membrane.

Lymph is thus found in spaces above and beneath the arachnoid membrane outside of the brain, as well as within the ventricles. The two systems of spaces communicate at the region of the fourth ventricle. The opening by which this communication is established has received the name of the *foramen of Majendie*. It lies in the centre of the roof of the fourth ventricle between the fasciculi gracili, and is in part occupied by the median vessels of the inferior choroid plexus. The normal quantity of intracranial lymph varies from two drachms to two ounces.

The Pacchionian Bodies are small, rounded or flattened bodies, of a yellowish or grayish color, commonly arranged in groups, but occurring singly as well, and situated for the most part near the longitudinal sinus. These structures are firmly associated with the dura mater or with depressions upon the under surface of the cranial vault. The bodies are believed to be the result of a hypertrophied condition of the villoid structures of the arachnoid membrane which penetrate the dura mater.

Remarks.—The results of pressure within the brain-case are well illustrated by the disturbances excited therein by a tumor, a blood-clot, or other foreign body. In order to accommodate the new occupant, the relations already existing between the normal contents of the brain-case must be modified. The brain cannot

yield, but the calibre of some of the larger vessels may, and the lymph can be displaced along the course of the perineural and perivascular sheaths, as the nerves escape and the arteries enter the skull. Such compensations are doubtless established immediately after the appearance of the intruding mass. That they are not constant and are not developed in any fixed ratio with the size of the mass, are results probably due to the nature of the part of the brain receiving it. Thus an intrusion in the prefrontal lobe, or into the tip of the occipital lobe, would be accompanied with less distress than would an intrusion in the neighborhood of the fissure of Rolando, or among the contents of the cerebellar fossa. The primary effects, in which the arteries may be assumed to be constricted, would be again different from the secondary effects, in which they may be assumed to be dilated.

The escape of the lymph from the external ear, in cases in which severe blows upon the head have been sustained, implies a fracture of the skull involving the subarachnoid space, the internal meatus, and the walls of the tympanic chamber.

In arachnoidean dropsy the lymph is confined to the upper and lateral parts of the surface of the brain; and as this is invariably the case, however great may be the quantity of the fluid, it cannot press upon the bones at the base. This strict limitation is, according to Prescott G. Hewett,[1] the most common form of arachnoidean dropsy, and is due to a more or less well-formed membrane acting like a cyst wall.

The lymph in the cerebellar fossa protects the cerebellum, the pons Varolii, and the medulla oblongata from pressure against the skull.—Tumors at the superior transverse fissure, viz., at the region of the corpora quadrigemina or of the pineal body, or in the isthmus of the brain, may prevent the flow of lymph from the lateral ventricles and the third ventricle along the *iter* into the fourth ventricle. Accumulations of lymph in the cavities of the brain (hydrops ventriculi) may arise from pressure at a point as remote as the medulla oblongata. In a case reported by Kohts,[1] a cystic tumor in the median lobe of the cerebellum, extending thence to the fourth ventricle, was found associated with a cherry-sized growth lying between the valve of Vieussens and the corpora quadrigemina. It is certainly possible in this case to account for the presence of a distended third ventricle which had forced downward the lamina cinerea and the optic chiasm, and had dilated the infundibulum, by referring it to the retention of lymph in the third ventricle owing to occlusion of the *iter*.

The sensations of vertigo and of noises in the ears are probably caused by sudden transposition of lymph-fluid into the posterior cerebellar fossa. In like manner the phenomena, so common in brain-diseases, of vomiting, irregular motions of the eyeballs, of paralysis of the facial muscles, of the tongue, or of one or more nerves to the muscles of the eyes, may be often attributed to pressure of the lymph either against the nuclei of the origins of the cranial nerves lying in the gray matter of the *iter* or beneath the floor of the fourth ventricle, or against the nerve-trunks as they pass from their apparent origins to their points of exit from the base of the skull.

The entire space beneath the base of the brain may be occupied by blood escaping from the ruptured basilar artery.[2]

[1] St. George's Hospital Reports, i., 1866, 25.

[1] Virchow's Archiv, vol. 67.

[2] Blachez, Bull. de la Soc. Anat., 37, 1862, 334.

THE PERIPHERAL NERVES.

The peripheral nerves are of two kinds, as follows:—

I. The Cranial Nerves.

II. The Spinal Nerves.

THE CRANIAL NERVES.

The cranial nerves are twelve in number, and are named from before backward in the order of their apparent origin at the base of the brain.

Cranial nerves are said to be segmental when they arise as parts of a right and of a left pair in the embryo from a median point on the dorsum of the brain.

The segmental cranial nerves are the first, third, seventh, ninth, and also the tenth nerve, which, however, is a result of fusion of several primoidal segmental nerves. The second optic (nerve) is of doubtful position, since it is a bud-like projection from the brain. The eighth nerve is a part of the same seg-

mental nerve as the seventh. The eleventh and the twelfth nerves are transitional between the cranial and spinal sets.[1]

Each cranial nerve has a *true* (deep, or real) *origin* from the group of cells constituting its nucleus; and an *apparent* (superficial) *origin*, which is the point at which the nerve escapes from the brain.[2] The fibres between the points of true and apparent origin will in this book receive the name of the *intrinsic fibres*. The portions of the nerve trunks lying between the apparent origin to the point of escape from the brain-case become *encranial*, and all the other portions *excranial*. All the remaining fibres, viz., those between the apparent origin and the terminal structures (which would thus become the *extrinsic fibres*), commonly include the *trunk of the nerve* and its *branches*.

Cranial nerves differ from spinal nerves in having definite nuclei of origin, as well as in having intrinsic fibres which can be isolated in microscopic studies of the brain. The position of the intrinsic fibres is commonly seen in oblique lines traversing, as a rule, the substance of the medulla oblongata and the stem of the brain from the dorsal to the ventral aspect, since, with the exception of the fourth nerve, the nuclei lie above (dorsad), *i. e.*, on a higher horizontal plane to, the points of escape of their respective nerves.

The relations of the cranial nerves, therefore, are complex. The intrinsic relations are with the surrounding nuclei, and the various nerve-tracts; the relations of the encranial portion at the base of the brain pertain to the arachnoid membrane, the dura mater, and the subarachnoid lymph space and bloodvessels. In the walls of the skull the relations pertain to the osseous barriers, and to certain bloodvessels. While beyond the skull they lie adjacent to bloodvessels, muscles, skin, mucous membrane, etc.

When the nuclei of origin or the intrinsic fibres of any cranial nerve are involved by diseased action or by the effects of injury, the palsy of the nerve is said to be *central*, but when the remaining portion of the nerve is involved the condition is said to be *peripheral*. Peripheral palsies are more frequently seen than those of central origin. The nerves most commonly palsied are the third, fifth, sixth, and seventh.

[1] See Balfour, Compar. Embryol. 374, and A. M. Marshall, Journ. Anat. Phys., 1882, p. 318.

[2] The points of apparent origin of the nerves are of importance topographically, in naming areas of the base of the brain, and in describing locations of sections. In like manner at the floor of the fourth ventricle, the superficial fibres of the eighth nerve serve to separate the pontal from the medullary portion; the sixth and seventh nerves arising from the pontal portion, and the ninth, tenth, eleventh, and twelfth from the medullary.

THE OLFACTORY OR THE FIRST NERVE.

The Olfactory, or the First Nerve, is the nerve of smelling.

It secures deep origins within the cerebrum through the medium of three peduncles or "roots" of the nerves as follows:—The external (lateral, long) root passes outwards as a band of white fibres along the anterior margin of perforated space to the temporo-sphenoidal lobe. The middle or gray root arises from the cortex covering the anterior perforated space. The internal (median) root arises from the frontal lobe, and passes to its medullary substance. The olfactory nerve sends fibres across the anterior commissure to the opposite cerebral hemisphere, and its fasciculi can be traced as far back as the occipital lobe. Meynert believes that the anterior commissure is in part an olfactory chiasm. He explains in this manner the occurrence of anosmia with hemianæsthesia when lesions exist in the occipital lobe.

The olfactory nerve, as it passes forward, lies within the straight sulcus on the under surface of the frontal lobe. The fusiform swelling ending the nerve lies over the cribriform plate of the ethmoid bone, through the openings of which filaments to the number of twenty pass to enter the nasal chambers. These filaments are distributed in faint lineal bony grooves into two sets: an outer set to the superior and the middle turbinated bone; an inner to the upper portion of the septum. They are somewhat larger than those of the outer division.

The ultimate arrangement of the fibres is somewhat plexiform. The nerves are lost between its fibrous and the mucous layers of the nasal mucous membrane.

Notwithstanding the fact that the olfactory nerve develops in the same manner as the other nerves, its cerebral connections are so pronounced as to give it a distinctive position, and it is convenient to regard the nerve as a portion of the encephalon projected forward from the main mass.

The olfactory bulb is of the significance of a distinct ganglionic centre, and its peduncles are of the nature of commissure. According to Meynert, it is hollow like the cerebral lobe in lower animals, its cavity communicating with the lateral ventricle. Above, its cortex is directly continuous with that of the free border of the cortex of the anterior perforated space. The olfactory bulb is complex in structure. The dorsal portion resembles the matrix of the cortex of the cerebrum, but incloses a small area of central gray substance, and a layer composed of cells termed the olfactory glomeruli. Above the glomeruli is a layer containing cells resembling the fusiform and pyramidal cells of the cortex of the cerebellum, and above this, layers of medullary tissue with closely arranged nerve cells.

The histology of the mucous membrane at the places corresponding to the terminations of the olfactory nerves is as follows:—

The epithelial cells are columnar, and extend downward by a long narrow branched basal process. Interspersed among the epithelial cells, and more numerous than they, are elliptical cells, containing a nucleus, nucleolus, and granular cell contents. These cells are distinguished by a long cylindrical process passing outward, and ending on a level with the free outer surface of the cylindrical epithelial cells. The basal process is small and unbranched. These last-mentioned cells are presumably olfactory in function, although neither these nor the epithelial cells have been shown to have connection with the olfactory nerve filaments.

The nerve is supplied at its apparent origin with blood by twigs from the anterior cerebral artery (Duret).

Remarks.—The olfactory bulb is absent in cyclops monsters. Bernard reports a case of its congenital absence in a brain which in other respects was normal. A knowledge of the deep cerebral connections of the olfactory nerve prepares us for the fact that lesions of the occipital and temporo-sphenoidal lobes cause anosmia. The temporo-sphenoidal lobe, as it forms the posterior border of the greater arm of the Sylvian fissure, has been supposed by Ferrier to be the locality within which lies the centre of coördination of the olfactory apparatus. — Blows upon the occiput are occasionally followed by anosmia. Three factors enter into the study of such a lesion. First, that the shock of the concussion may be expended on the brain as it overlies the frontal plates (there being at this region no subarachnoid fluid buoying up the frontal lobes, such as exists in the middle and posterior cerebral fossæ), and the olfactory bulbs be lacerated. Second, that a shock similar to the preceding may fracture the frontal bone, or the cribriform plate of the ethmoid bone, and the fragments lacerate the olfactory bulb. Third, that the concussion of the occipital and temporo-sphenoidal lobes may initiate diseased processes which result in degeneration of the cerebral nerve cells controlling olfaction.

C. S. Bull[1] reports a case remarkable for the destruction of the right olfactory nerve from pressure exerted against it by a sarcomatous tumor which originated from the floor of the anterior cerebral fossa. The growth had involved secondarily both optic nerves.

[1] Phila. Med. Times, 1875, 225.

The Optic or the Second Nerve.

The Optic, or the Second Nerve, is the nerve of sight. The optic nerves, unlike others of the cranial series, undergo a decussation in their encranial portion. The region of the decussation is called the optic chiasm. The nerve-trunk between the apparent origin and the chiasm is called the optic tract; and the portion between the chiasm and the terminus of the nerve is called the optic nerve proper.

The *optic tract* (fig. 2, Plate LXXX., fig. 4, Plate LXXXII.) arises from the anterior lobes of the corpora quadrigemina, and from the geniculate bodies. Fibres can be traced also to the occipital lobes of the cerebrum and the optic thalamus. Each nerve is obscurely separated into two roots, an external and an internal. The external root (antero-lateral) arises from the optic thalamus—the external geniculate body and the anterior tubercles (nates) of the corpora quadrigemina. The internal root (postero-lateral) is in structural relation with the posterior tubercles and with the intermediary part of the internal geniculate body, or the middle root of some writers.

Huguenin gives the following for the origin of the optic tract:—

(1.) An outer root arising from the optic thalamus near its surface, and from the external geniculate body, and through it from the posterior thalamic tubercle (pulvinar).

(2.) An inner root from the internal geniculate body uniting the body with the posterior tubercle of the quadrigeminal mass.

These roots bring the optic tract in connection with the tegmentum through the thalamus; with the cortex of the occipital lobe, through the fibres which radiate from the corpora quadrigemina; and with the fillet, through the fibres descending from the corpora quadrigemina.

The optic tract thus constituted is a ribbon-shaped band which advances obliquely forward and inward, close to the crus cerebri. Each tract defines the anterior limit of the crus of its own side. It further aids in defining, and is in intimate relation to, the tip of the temporo-sphenoidal lobe. Just before joining the chiasm, the tract becomes more cord-like, and is in intimate union with the tuber cinereum and the lamina cinerea.

The *optic chiasm* (optic commissure) is a flat structure, quadrate in outline, longer from side to side than from before backward, the angles being formed by the optic tracts and optic nerves. It lies on the olivary eminence of the sphenoid bone. Behind it is the lamina cinerea with which it is united; in front,

the anterior longitudinal fissure of the cerebrum; at the sides, the internal carotid arteries. The chiasm is composed of four sets of fibres: a decussating set in the centre, made up of a right and left set derived from the median half of each optic tract; a right lateral set; a left lateral set; and a commissural set (inferior commissural set of Gudden) which extend between the two inner geniculate bodies, along the median borders of the optic tracts, and along the posterior border of the chiasm.

The *optic nerve* proper is a rounded cord about one inch long. It extends forward and outward from the antero-lateral border of the chiasm to the optic foramen of the sphenoid bone, through which, in company with the ophthalmic artery (which lies to its outer and lower side), the nerve escapes from the cranium. The orbital portion is inclosed in a sheath of dura mater and pia mater; receives in its interior, at its middle, or at a point slightly in advance, the central artery and vein of the retina; and terminates in the posterior surface of the eyeball, at a point a little to the inner side and below the centre.

The optic nerve has two distinct sets of relations: one encranial, and the other orbital (excranial). The *encranial* relations are with the membranes of the brain, the floor of the anterior cerebral fossa beneath, and the olfactory nerve to its median (inner) side. The common trunk of the anterior and middle cerebral arteries lies a little to the outer side of the optic nerve. The *orbital* relations are more complex. The nerve is surrounded by fat, which serves to separate the nerve from the Recti muscles. In the fat are imbedded the ophthalmic ganglion and the ciliary nerves and bloodvessels. Above the nerve is the nasal branch of the ophthalmic artery. In the outer side is the ophthalmic ganglion. The optic nerve is not straight, but slightly curved, the convexity of the curve being directed outward.

Variations.—The chiasm may be absent, in which event each nerve runs to the eye of the corresponding side. In the body of an epileptic a thin band of nerve-fibres was seen by Ganser[1] to separate itself from the right optic tract a little in front of the corpora geniculata, to pass forward on the ventral surface of the tract to the lateral border of the chiasm and the nerve, and afterward to become incorporated with the nerve.

The *lymphatics* of the optic nerve are described with the lymph-spaces. (See Arachnoid.)

The *bloodvessel supply* of the optic nerve and tract is variable. The following statements respecting it are abridged from the writings of Duret:[1]—The optic nerve derives twigs from the ophthalmic artery, or from the anterior cerebral and internal carotid arteries. The optic chiasm is supplied by the anterior communicating, the internal carotid, and the anterior cerebral arteries. The optic tract is supplied by the anterior artery of the choroid plexus; the geniculate body, at times, by the posterior cerebral and posterior communicating arteries.

It is difficult, if not impossible, to have the optic nerve and tract impaired by emboli or other causes of obliteration of blood supply. The vascular complications within the eye so frequently associated with encranial disease are not excited by purely mechanical causes, but are to be studied as related to the general conditions maintained by cerebral or other lesions.

Remarks.—The practical applications of a knowledge of the anatomy of the optic nerves can be considered under the following heads: (*a*) the connection between the optic nerve, the occipital lobe of the cerebrum and the corpora quadrigemina; (*b*) the connection between the optic tract and the chiasm; (*c*) the optic nerves; and (*d*) the retina.

(*a*) In connection with the value of remembering the relations between the occipital convolution and the corpora quadrigemina, the following may be cited: A federal soldier was wounded in the occiput at the battle of Antietam. The ball entered one inch and a quarter above the external occipital protuberance, passed forward and to the left three inches, and escaped at a point two inches to the left of the median line. A fungus cerebri followed forming a mass the size of the fist, which was several times removed. Recovery ensued, but crossed *right* hemiopia (*i. e.*, nasal hemiopia of left eye; temporal hemiopia of the right eye) remained. The lesion in this case most probably invaded the cerebral fasciculi arising from the corpora quadrigemina, and excited permanent disturbance in the left optic tract.[2]

In the experiments of Gudden[3] it was found that, after extirpation of the eyes in young rabbits, atrophy of the above part ensued, while the posterior tubercles of the corpora quadrigemina (testes), and the internal geniculate body remained unaffected.—In a woman who was ataxic and had been blind for fifteen years the corpora quadrigemina and the brachia were found by Charcot[4] to have undergone marked atrophy.

[1] Archiv für Psychiatrie, 1882, xiii. 341.

[1] Archives de Physiologie, 1874, 951.

[2] W. W. Keen and W. Thomson, Photographic Review of Medicine and Surgery, Phila., Feb. 1871; copied in Trans. Am. Ophth. Soc. 1871, 122.

[3] Archiv für Ophthalmologie, xv.

[4] Leçons, p. 137.

(*b*) The fibres of the median (inner) border of both tracts completely decussate and pass to the inner aspect of both eyeballs. Hence pressure exerted against such fibres will cause paralysis of the nasal (median) half of each eye, *i.e.*, will cause nasal hemiopia. A growth at the base of the brain to the median side of the optic tracts, *i.e.*, in the region of the pituitary body, will be apt to excite such pressure.[1]

The outer fibres do not decussate, and consequently their disorder or destruction will be followed by paralysis of the temporal (lateral) half of each retina, *i. e.*, lateral (temporal) hemiopia will be created. Dr. H. Knapp[2] reports a case in which this condition existed. At the autopsy the arteries composing the circle of Willis were found to be in a highly atheromatous state. In the opinion of the recorder, "a temporary partial obstruction in the circle of Willis produced an impediment of the current of blood, swelling of the arteries, lateral pressure on the chiasm and optic nerves, and exudation into the arachnoid cavity, which travelled through the intervaginal space of the optic nerves into the eyes, causing neuro-retinitis, impairment of sight, and atrophy of the optic nerves." The important fact in connection with the relation of the optic chiasm is the following: "The lateral (temporal) hemiopia was occasioned by direct pressure of the swollen, stretched, and probably inflamed arteries on the lateral fasciculi of the chiasm and the optic nerves."

Lesion of the entire optic tract of one side will cause lateral (temporal) hemiopia of the same side and median (nasal) hemiopia of the opposed side.

Lesion of the central fibres of the chiasm will cause median hemiopia of both eyes. Lesion of the lateral fibres, lateral (temporal) hemiopia of its own side.

Lesion of one optic nerve at its lateral half will cause lateral (temporal) hemiopia of its own side.

Lesion of the optic nerve at its median half will cause median (nasal) hemiopia of its own side.

The fasciculi in the left optic tract will pass to the left half of each eye. The fasciculi in the right optic tract will pass to the right half of each eye.[3]

Hirshberg[1] reports a case of cerebral gliomatous tumor the size of an apple, which was lodged in the right frontal lobe, and compressed and flattened the optic tract of the corresponding side. Temporal hemiopia of the right eye and nasal hemiopia of the left eye resulted.

J. S. Bristowe[2] has reported an example of a tumor originating in the third ventricle, which extended downward and forward and pressed upon the optic chiasm.

The chiasm may be involved in the effects of chronic meningitis, and be firmly adherent to the dura mater.

The direct relation existing between the optic tract and the temporo-sphenoidal lobe of the cerebrum should be borne in mind in clinical studies of these structures.

(*c*) The optic nerve may be wounded by bullets or other missiles penetrating the brain case, or be torn in fracture of the base of the skull. In the lesion last named a fissure in the base of the skull may, as not seldom happens, open into the optic foramen, lacerate the sheath of the optic nerve, and permit blood to flow into the perineural lymph space. The clot of blood thereby resulting will induce choked disk. The optic nerve may be raised and stretched by a tumor growing from the pituitary body, as reported by Wagner.[3]

Although the optic nerve lies at the base of the brain, its distance from the vertex is not so great but that compound fracture of the frontal bone may not expose it. Mr. James Dickson[4] reports a case in which the optic chiasm and upper part of the right eyeball were thus seen by the observer after such an injury. The patient recovered with good vision.

(*d*) For lesions of the retina, see Eye.

THE OCULO-MOTOR, OR THIRD NERVE.

The Oculo-Motor, or Third Nerve, supplies the muscles of the orbit, with the exception of the External Rectus and the Superior Oblique. It also supplies the Ciliary muscle and the Sphincter Pupillæ. It arises from a *nucleus* lodged in the floor of the *iter* at its middle third, near the median line, and to the inner side of the posterior longitudinal bundle. Directly in front of it lies the nucleus of the fourth nerve. The nucleus receives fibres from the corpora quadrigemina. The *intrinsic fibres* of the oculo-motor

[1] For cases illustrating the effects of such pressure see Saemisch (Zeh, Klin. Monatsbericht, 1865, 51), and D. E. Müller (Græfe, Archiv für Ophthal., viii., 1861, 160).

[2] Archives of Scientific and Practical Medicine, New York, i. 293.

[3] The arrangement of the fibres in the optic tract is the one adopted by Charcot and by most ophthalmologists. It is necessary to state, however, that some observers do not accept that a total decussation occurs in the optic chiasm. In connection with this, see E. Mandelstamm (Archiv für Ophthalmologie, 1873, 39), for anatomical observations, and H. C. Bastian (Lancet, 1874, July, 112). See also W. Schoen (Archiv der Heilkunde, 1875, 1), and Schmeigger (Archiv für Ophthalmologie, 1876, 276).

[1] Virchow's Archiv, 1875, t. 5, 116.

[2] Trans. Path. Soc. Lond., 1873, 11.

[3] Virchow's Archiv, 1875, 219.

[4] Glasgow Med. Journ. vol. iii. 1855–56, 318.

pass downward through the red nucleus, and, collecting in a bundle, secure an *apparent origin* at the median side of the crusta (fig. 2, Plate LXXX.).

The nerve passes forward and slightly outward, pierces the dura mater at the anterior border of the internal carotid artery, lies beneath the anterior clinoid process, and traverses the upper wall of the cavernous sinus. In the encranial portion of its course, the third nerve lies at first between the posterior cerebral and the superior cerebellar arteries, the posterior communicating artery afterward lying to its outer side. It lies beneath the optic tract, and, near its termination, between the anterior cerebral arteries.

It enters the orbit (figs. 1 and 2, Plate LXXXIV.; Plate XCI.) through the sphenoidal fissure, between the two heads of the External Rectus muscle. Near the median border of the sphenoidal fissure and over the optic nerve the main trunk divides into two branches, the upper and the lower. The *upper branch* passes over the optic nerve to supply the Superior Rectus, and sends a branch along the outer border of the muscle last named to the Levator Palpebræ. The *lower branch* passes downward and forward to supply the Inferior Rectus, the Internal Rectus, and the Inferior Oblique muscles, as well as to send a *short branch* to the ophthalmic ganglion.[1]

The branches of the oculo-motor nerve are accordingly as follows:—

Upper Branch (Lies above optic nerve and nasal branch of the ophthalmic).	Superior Rectus.
	Levator Palpebræ.
Lower Branch	Internal Rectus.
	Inferior Rectus.
	Inferior Oblique.
	Short Branch to ophthalmic ganglion.

Variations.—Schwalbe describes a minute rootlet (lateral root) having its apparent origin from the side of the crusta. The third nerve may send a branch to supply the External Rectus in subjects in which the sixth nerve is absent. It may send a branch to the Superior Oblique muscle. A small branch has been described by Bock as entering the eyeball. A branch may connect the nerve with the nasal branch of the ophthalmic nerve.

Remarks.—The nucleus of the third nerve may be compressed by a tumor of the corpora quadrigemina, or by the swelling following dropsy of the ventricles. Degeneration of the pyramidal tract will not directly involve this nerve; but cases have been recorded in which paralysis of the nerve was found associated with degeneration of central origin. Its intrinsic fibres could be involved by diffusion of degeneration spreading from the pyramidal tract upward and inward.

In the movement of the eyeballs, inward and downward, as in the act of accommodation, the fibres of the oculo-motor nerve distributed to the Internal Rectus and the Inferior Rectus act independently of the fibres distributed to the Superior Rectus and the Levator Palpebræ. The two sets of fibres pass to antagonistic muscles. The entire set of muscular branches act synergetically with the External Rectus and the Superior Oblique in nystagmus, but on the whole the third is in closer affinity with the fourth than with the sixth nerve.

The muscles supplied by the nerve may be each the subject of paralysis. The most common and striking instance of this is the paralysis of the Levator Palpebræ, causing ptosis. In paralysis of the entire nerve, due to inflammatory thickening of its sheath, to pressure from tumors, or to central degenerative lesions of the nucleus, the eyeball is fixed, or turned slightly outward and downward, the eyelid falls, and the pupil is dilated. The nerve has been found by Türck flattened against the posterior clinoid process by an exudation in the ventricles. J. G. Bristowe[1] describes the nerve as displaced by a tumor in the third ventricle pressing downward and outward. According to Wernicke, it may be squeezed between the posterior clinoid processes and the pons by a tumor originating from the pons. It is frequently paralyzed by the pressure of inflammatory products in basal meningitis, either acute, as in tubercular meningitis, or chronic, as in syphilitic meningitis, or by a gumma or other tumor.

THE PATHETICUS, OR THE FOURTH NERVE.

The Patheticus, or Fourth Nerve, supplies the Superior Oblique muscle with motor filaments. The nerve is the smallest and most slender of those of the cranial series. It arises from the *nucleus* lying beneath the *iter*, and behind the nucleus of the third nerve, on a plane answering to the boundary between the anterior and posterior tubercles of the corpora quadrigemina. The *intrinsic fibres* pass gradually to the dorsal region of the *iter*, and at the valve of Vieussens decussate with the fibres of the nerve of the opposite side. The fibres become *apparent* at the dorsum of the stem of the brain close behind the corpora quadrigemina (fig. 6, Plate LXXXII.), and, winding round

[1] For description of this ganglion, see Fifth Nerve.

[1] Trans. Path. Soc. Lond., 1873, 11.

the side of the crus (fig. 2, Plate LXXX.), pierce the dura mater beneath the tentorium. Reaching the base of the brain, the nerve passes forward (Plate XCI.), to enter the cavernous sinus, along the upper and outer side of which it lies in company with the third nerve (fig. 2, Plate LXXXIV.). The nerve enters the orbit through the sphenoidal fissure in company with the ophthalmic nerve, is distributed to the Superior Oblique muscle on its upper surface, and sends a recurrent branch to the tentorium as it passes through that membrane. The nerve is protected along the greater part of its course by the dura mater. It is nourished by a twig of the posterior cerebral artery.

Variations.—The patheticus, as it lies in the cavernous sinus, may send a branch of communication to the fifth nerve.[1] It frequently sends a branch to join the carotid plexus. A small filament has been traced to the lachrymal nerves. The nerve may unite with the ophthalmic branch of the fifth nerve, and with the infra-trochlear nerves. Two encranial nerves may be seen on each side, which unite as they enter the orbit.

Remarks. — The patheticus nerve may be separately paralyzed.

THE TRIFACIAL, OR THE FIFTH NERVE.

The Trifacial Nerve supplies sensory branches to the region of the face, the forehead, the external ear, and the lining membrane of the middle ear; and motor branches to the muscles elevating the lower jaw. In addition it gives sensation, and in a measure controls the sense of taste, at the anterior two-thirds of the tongue; and it is the secretory nerve to the lachrymal gland.

The fifth is the largest of the cranial nerves, and represents to a greater degree than any of them the component parts of a spinal nerve. Its *deep origin* is from an extensive tract of gray matter in the stem of the brain and the medulla oblongata. Two "roots" are recognized which have received the names of the motor and the sensory root.

The *motor root* is the smaller of the two, and arises from a *nucleus* in front of the lower facial nucleus, as well as from the gray matter at the floor of the *iter* at its anterior portion, beneath the corpora quadrigemina. The fibres arising from the nucleus last named form the *descending root*, which being joined by various fibres forms the raphe.—The *sensory root* receives most of its fibres from the *ascending root*, which originates in the gray matter of the spinal cord. Fibres also arise, according to Meynert, from the cerebellum at the outer side of the superior peduncle of that body, as well as from the upper portion of the gelatinous substance as it forms the tubercle of Rolando at the level of the apparent origin of the nerve. Through the agency of the fibres originating at the *iter* and near the corpora quadrigemina, the fifth nerve is supposed to be connected with the posterior lobe of the cerebrum, since hemianesthesia and disturbed states of function of the fifth nerve are conditions frequently found associated.

The fibres of *apparent origin* of the nerve pierce the side of the pons Varolii at the point where this structure is continuous with the middle peduncle of the cerebellum (fig. 2, Plate LXXX.; fig. 4, Plate LXXXIII.). The orifice of exit is nearer the anterior than the posterior border, and nearer the upper than the lower.

The sensory and motor roots are distinctly limited at the place of apparent origin, and remain separate through the entire length of the encranial portion of the nerve, the small compact motor trunk lying on the under median side of the larger sensory trunk. Toward the apex of the petrous portion of the temporal bone the nerve enters a slit-like opening of the dura mater, which is situated to the outer side of the orifice for the exit of the sixth nerve. Directly beyond this opening, and inclosed by the dura mater of the middle cerebral fossa, is a large ganglion lodged on the sensory trunk, which has received the name of the *ganglion of Gasser* (semilunar ganglion) (fig. 2, Plate LXXXIV.). The ganglion of Gasser is broad, and somewhat crescentic in form, the convexity being directed forward, and lies in a shallow depression on the apex of the petrous portion of the temporal bone. The motor trunk lies beneath the ganglion a little to the median side. The ganglion is joined by several filaments from the carotid plexus.

The trunk of the fifth nerve is confined to the cranium, and ends at the anterior border of the ganglion of Gasser in three great branches, the ophthalmic, the superior maxillary, and the inferior maxillary nerves. Each of these exhibits a short encranial portion.

Branches of the Fifth Nerve:—

Ophthalmic.
Superior Maxillary.
Inferior Maxillary.

The Ophthalmic Nerve (Plate LXXXIV., Plate XCI.).—The ophthalmic nerve is a somewhat flattened cord of about an inch in length, and is the smallest branch of the main nerve. It enters the

[1] Luschka, Die Nerven in der Hirnhauten, Taf., 1, 1850.

cavernous sinus, passes forward and upward along its outer wall, and effects its escape from the brain-case at the anterior lacerated foramen. Within the orbit, it divides into its three terminal branches, the frontal, the lachrymal, and the nasal.

Branches of the Ophthalmic Nerve:—

Branches in the Cavernous Sinus,
Frontal Nerve,
Lachrymal Nerve,
Nasal Nerve.

The Branches in the Cavernous Sinus embrace branches of communication with the carotid plexus: a branch may join the third nerve; another the sixth nerve; and a third may join the fourth nerve. A branch of different significance, since it is distributed to the dura mater, passes to the tentorium. From the circumstance that this twig lies in the sheath of the fourth nerve, some writers have described it as a branch of that nerve.

The Frontal Nerve is the axial continuation of the main trunk of the ophthalmic nerve. It passes horizontally forward between the periosteum of the roof of the orbit and the Levator Palpebræ muscle, which it crosses at an acute angle, and divides at a point a little back of the orbit into two unequal branches, the supra-trochlear and the supra-orbital nerves. The *supra-trochlear nerve* is, as a rule, smaller than the supra-orbital, and passes across the orbit obliquely from without inward, escaping near the pulley of the Superior Oblique muscle. It then pierces the Orbicularis Palpebrarum, and, turning upward on the forehead, terminates in the integument. Near the upper border of the Superior Oblique the nerve sends a branch to join the infra-trochlear branch of the nasal nerve, and to give filaments to the upper eyelid and to the root of the nose (fig. 1, Plate LXXXV.).

The *supra-orbital nerve* is the continuation of the frontal branch. It escapes from the orbit by the supra-orbital, and divides into a median and a lateral branch. Both branches pierce the Orbicularis Palpebrarum and the Occipito-Frontalis, and supply the skin of the forehead and the parietal region. Of the two, the median branch is the smaller.

In addition to the above, several small branches pass vertically downward in the substance of the upper eyelid, a filament extending horizontally outward under the Orbicularis Palpebrarum to anastomose with the facial nerve.

A small filament supplies the periosteum of the frontal bone, and, according to Cruveilhier, may enter a minute osseous canal near the supra-orbital foramen, emerging at the frontal eminence to become subcutaneous.

The Lachrymal Nerve is the smallest of the branches of the ophthalmic nerve, and enters the orbit through the upper part of the anterior lacerated foramen. It lies near the outer orbital wall in close connection with the periosteum, and extends along the upper border of the External Rectus muscle to the region of the lachrymal gland. It divides into two branches, a superior and an inferior. The *superior branch* sends filaments directly to the lachrymal gland, to the conjunctiva, and to the skin in the neighborhood of the external canthus and upper eyelid. The *inferior branch* receives a branch of communication from the orbital branch of the superior maxillary nerve. It may pass through an osseous canal in the outer wall of the orbit. From the arc resulting from the union branches pass to the lachrymal gland.

Variations.—In the absence or reduction of the lachrymal nerve, the orbital branch of the superior maxillary nerve may take its place. When a branch of the fourth nerve apparently passes to the lachrymal gland, it is thought that a branch of the lachrymal nerve passes along in the sheath of the fourth. In connection with this it is of interest to note the branches of the fourth nerve to the appendages of the eye in batrachia.—A small branch may supply the integument of the anterior portion of the region of the temple.

The Nasal Nerve arises from the under side of the ophthalmic trunk, and enters the orbit at the largest part of the anterior lacerated foramen, in company with the fourth nerve, and between the superior and inferior branches of the third. The nerve lies to the median side of the frontal nerve, and, piercing the ligament from which arises the External Rectus, and passing between the two heads of this muscle, is inclined obliquely inward, across the optic nerve, and between it and the Levator Palpebræ, the Superior Oblique and the Superior Rectus muscles, reaches the median aspect of the orbit at the anterior ethmoidal foramen, where it divides into the internal nasal and the infra-trochlear nerves.

The *internal nasal nerve* is in the line of continuation of the nasal nerve. It passes from the orbit into the brain-case through the anterior ethmoidal foramen, where it is held by a doubling of dura mater. It there runs a short distance to the outer side of the olfactory groove of the ethmoid bone, to descend vertically behind the ethmoidal wing into the nose. It finally divides into two branches; the external and the internal branch. The *external* (anterior branch) forms for itself a canal or groove on the under surface of the nasal bone, and either obliquely perforates this structure to become superficial, or continues downward to the free border of the bone,

to pass between it and the upper lateral cartilage, being then lost in the skin of the tip and ala of the nose. *The internal* branch (septal branch) is the smaller. It crosses the roof of the nose, and is distributed to the anterior portion of the mucous membrane of the nasal septum. Filaments pass also to the mucous membrane of the middle and inferior turbinated bones, and to the lateral wall of the nose.

The *infra-trochlear* nerve is the remaining terminal branch of the nasal nerve. It leaves the main nerve as it lies beneath the Superior Oblique muscle. After receiving a small filament from the supra-trochlear nerve, it escapes from the orbit at the position of the pulley. It divides into two sets of branches: one passing to the superficial structures of the upper eyelid; and the other supplying the skin at the root and sides of the nose, the caruncle, the lachrymal sac, and the duct.

Before division, the nasal nerve gives off the following branches: A small filament to the dura mater of the anterior cerebral fossa. A branch to the ophthalmic (lenticular) ganglion, which arises from the trunk, before entrance into the orbit, or between the heads of the External Rectus. It lies to the outer side of the optic nerve, and constitutes the *long root of the ophthalmic ganglion.*

The *spheno-ethmoidal* branch[1] passes through the posterior ethmoidal foramen, and thence goes to supply the mucous lining of the sphenoidal sinus, and the posterior ethmoidal cells along the anterior border of the body of the sphenoid bone.

The *long ciliary* nerves, two or three in number, are placed to the inner side of the optic nerve. They are in connection with filaments from the short ciliary nerves (q. v.), pierce the sclerotic coat of the eyeball, and are distributed to the anterior portion of the eye, including the ciliary muscles, cornea, and iris.

A few distinct filaments join the sympathetic network about the ophthalmic artery.

THE SUPERIOR MAXILLARY NERVE.

The Superior Maxillary Nerve (fig. 3, Plate LXXXIII.; Plate LXXXIV.; Plate XCI.) passes from the cranium through the round foramen of the sphenoid bone. It is at its origin somewhat loosely fasciculated, but soon becomes firmer as it crosses the pterygo-maxillary fossa, where it is surrounded by fat. The nerve pursues a nearly straight course, with a slight inclination downward, to be received within the superior maxilla in the infra-orbital canal, where it receives the name of the infra-orbital nerve. The *infra-orbital nerve* terminates at the infra-orbital foramen by an intricate bundle of branches lying beneath the Levator Labii Superioris.

Branches of the Superior Maxillary Nerve—

Anterior Dental	Ascending.
	Descending.
Orbital	Lachrymal.
	Temporo-malar.
Posterior Dental	
Terminal	Ascending.
	Descending.
	Internal.

Just before the infra-orbital nerve terminates, it gives off the *anterior dental* branch. This takes an unusual course, as follows: It passes from the main nerve horizontally inward, lying within a special canal, then vertically downward, turning around and parallel to the margin of the anterior opening of the corresponding nasal fossa, and is reflected on the floor of the fossa. About two lines from the anterior orifice it expands into a great number of ascending and descending filaments, which pursue, for the most part, a curvilinear course; the *ascending* reflected upward within the anterior nasal spine, where they terminate; the *descending*, supplying branches to the incisors, canines, and first bicuspid teeth. Some of the filaments incline outward, and anastomose with branches of the posterior dental nerve. In the first and third portions of the above course, the nerve is deeply situated; in the second it becomes very superficial, and approaches the external table of the bone.

The remaining branches of the superior maxillary nerves are the orbital, the superior dental, and the terminal.[1]

The *orbital branch* (subcutaneus malæ) arises directly in front of the round foramen, from the upper side of the trunk, and passes through the spheno-maxillary fissure to the floor of the orbit, along the lateral wall of which it gives off the temporo-malar branch.—The *temporo-malar* branch pierces the orbital portion of the malar bone, and passes into the anterior part of the Temporal muscle to join the anterior deep temporal branch of the inferior maxillary nerve. The temporal division perforates the temporal aponeurosis about one inch above the zygoma, and ends in cutaneous filaments over the temple. The malar division lies at first in the loose fat at the lower angle of the orbit, then pierces the

[1] Described as constant by Luschka (Arch. f. Anat. u. Physiol. 1857, 313, fig.), as a variety by Bankart, Pye Smith, and Phillips, Guy's Hosp. Rep. xiv. 452.

[1] In the description of these branches, and other parts of the fifth nerve, Cruveilhier has been accepted as authority.

malar bone at its lower portion, and divides into two filaments, to anastomose with the facial nerve. The terminal filament of the orbital nerve joins the lachrymal branch of the ophthalmic nerve, and with it supplies the lachrymal gland.

The *posterior dental* nerves (alveolar nerves) arise from the superior maxillary nerve within the pterygo-maxillary fossa. They are arranged in two sets, the superior and the inferior. The *superior set* pass through the base of the malar process of the superior maxilla, and are distributed to the canine fossa, and anastomose with the anterior dental. The *inferior set*, larger than the preceding, curve below the malar process, and passing through the posterior dental foramina, supply the molar teeth, and the outer wall of the maxillary sinus, also giving filaments to the alveoli, and the gum. Some minute branches terminate within the superior maxilla.

The *terminal branches* (fig. 1, Plate LXXXV.) of the infra-orbital nerve are arranged in three sets, the ascending, the descending, and the internal. The *ascending*, which are slender, and generally two in number, lie in a groove or canal of the bone, and penetrate the fibres of the elevator of the upper lip, to be distributed to the skin and conjunctiva of the lower eyelid. They give filaments to the facial at the outer angles of the eye. Among these branches is one which is directed inward, and which anastomoses with the external nasal. The *descending* are more numerous than the preceding. They are distributed to the skin of the upper lip and its glands, and to the mucous membrane, and adjacent gum as well. The *internal* are distributed to the skin of the wing of the nose as well as to the outer skin, lining of the nasal chamber, near the nostril.

Just before escaping from the brain-case the superior maxillary division gives off a small filament to the dura mater of the middle cerebral fossa about the middle meningeal artery, and the great longitudinal sinus.—While in the pterygo-maxillary fossa, the nerve sends several filaments to the spheno-palatine ganglion.

THE INFERIOR MAXILLARY NERVE.

The Inferior Maxillary Nerve (fig. 3, Plate LXXXIII.; fig. 2, Plate LXXXIV.; fig. 1, Plate LXXXV.; Plate XCI.) escapes from the brain-case through the oval foramen of the sphenoid bone. It descends vertically, and divides into two great branches: (A) an anterior and smaller branch, which is for the most part motor, and (B) a posterior or larger branch, which is in the main sensory.

(A) The anterior root divides into the following branches:—

The Deep Temporal.
The Masseteric.
The Internal Pterygoid.
The External Pterygoid.
The Mylo-hyoid.
The Buccal.

The Deep Temporal Nerves arise a little distance below the oval foramen, commonly by two roots. The *anterior root* unites with the sensory filaments of the buccal where the latter nerve runs through or beneath the External Pterygoid muscle. The *posterior root* is entirely motor. The nerve passes at first forward, then obliquely upward and outward, and finally vertically upward through the deep part of the Temporal muscle. It perforates the temporal fascia about a finger's breadth above the zygomatic arch, and then ascends beneath the skin to anastomose with the auriculo-temporal and the facial nerve.

The Masseteric Nerve, larger than the preceding, arises from the main nerve by a thick root behind the deep temporal, with which it may have a common stem. It passes backward and outward in contact with the roof of the zygomatic fossa, between it and the External Pterygoid muscle. It is then reflected downward over the upper part of the muscle to gain the sigmoid notch, upon which it is again deflected to descend vertically between the ramus and the deep surface of the Masseteric muscle. The branches of the nerve are: a small branch of union with the deep temporal; a separate branch to the Temporal muscle, called the *deep posterior temporal;* and a branch to the temporo-maxillary articulation.

The Internal Pterygoid Nerve. This, the shortest branch of the inferior maxillary nerve, is interesting from its connection with the palate and ear. It arises from the anterior and internal side of the trunk, on a level with the otic ganglion. It runs constantly between the lingual nerve and the otic ganglion, often passing through the latter structure from before backward to gain the inner side of the Internal Pterygoid muscle. It sends a motor root to the otic ganglion, a twig to the Tensor Palati, and delicate filaments which traverse the ganglion to go to the Tensor Tympani.

The External Pterygoid Nerve. As a rule this branch is confined in its distribution to the muscle of the same name, and is often a twig from the preceding branch. Sometimes it arises in common with the buccal.

The Mylo-Hyoid Nerve. This nerve, generally

recognized as a branch of the inferior dental, is regarded by Luschka and Sapolini as a motor nerve, and as such is traceable to the motor trunk of the inferior maxillary nerve. As its name implies, it is distributed to the Mylo-hyoid muscle. It lies within a faint groove on the inner side of the lower jaw, where it is confined by fibrous membrane. Some of its filaments pierce the Mylo-hyoid muscle to join the lingual nerve.

According to Sapolini, a motor branch of the inferior maxillary nerve passes along the entire length of the inferior dental canal, to be lost in the soft parts about the mental foramen.

The Buccal Nerve (buccinator nerve) arises from the outer side of the inferior maxillary nerve by from one to three roots, which either pass between the heads of the External Pterygoid muscle, or pass between it and the Internal Pterygoid muscle. It is then directed downward, between the coronoid process and the tuberosity of the superior maxilla, and becomes superficial midway between the lobe of the ear and the angle of the mouth. It gives off the following branches:—

(*a*) Two or three Muscular Branches to the External Pterygoid muscle.

(*b*) The Temporal Branch (anterior deep temporal) penetrates the thickest portion of the Temporal muscle, and ordinarily unites with the deep temporal nerve.

(*c*) A Descending Branch supplies the Temporal muscle near its insertion.

Upon the cheek, the buccal nerve is divided into an upper and a lower branch. The *upper* is cutaneous, and goes to the skin of the malar and buccal regions. One of them forms an anastomotic arch with the facial, behind the parotid duct. The *lower* branches are in part cutaneous about the oral angle; others pierce the Buccinator muscle, to be distributed to the buccal mucous membrane.

Turner records an example in which the motor branches of the buccal nerve arose from the inferior maxillary nerve, while the branches to the mucous membrane were derived from the superior maxillary nerve.

B. The sensory division of the inferior maxillary nerve is divided into the following branches:—

The Auriculo-Temporal.
The Lingual.
The Inferior Dental.

The Auriculo-Temporal Nerve. This arises by two unequal roots, between which is seen the internal maxillary artery. The roots soon unite to form a flattened trunk inclined with a convex border outward toward the condyle of the lower jaw. It then winds round the neck of the condyle, and divides into an ascending and a descending portion.

The *ascending* portion passes vertically between the articulation and the external auditory meatus. It becomes subcutaneous, and divides into several filaments, which may be traced to the highest point of the temporal fossa. During its course the nerve gives off a very remarkable *anastomotic branch;* this branch arises behind the neck of the condyle, and is reflected upon it so as to run forward beneath the facial nerve, with which it is blended opposite the posterior border of the Masseter muscle. It may be regarded as a tributary to the facial, which becomes notably larger after receiving it. The main nerve gives off some *plexiform branches* directed horizontally backward to the temporo-maxillary articulation, as well as to the auditory meatus, which they enter between the osseous and cartilaginous portions, a branch going to the tympanic membrane. Of these branches, the auricular pass through the space between the tragus and helix to the concave surface of the auricle; a filament is directed toward the handle of the malleus, and a small branch joins the otic ganglion. The main nerve accompanies the temporal artery, about which it forms a sort of plexus, and then divides into cutaneous filaments, traces of which can be detected as far as the crown of the head. Rarely a branch of communication unites it with the occipital.

The *descending portion* of the nerve is as large as the ascending portion. It forms a plexiform arrangement of fibres about the internal maxillary artery, behind the condyle, and sometimes presents a small ganglion. Its branches go to the parotid gland; others anastomose with the auricularis magnus nerve; while another extremely fine filament joins the inferior dental nerve.

(*d*) The Lingual Nerve (gustatory nerve) lies between the Pterygoid muscles, to the inner side and in front of the dental nerve. It lies directly beneath the mucous membrane, opposite the lower molar teeth, and passes thence beneath the alveolo-lingual groove, to the side of the tongue. It is joined by the chorda tympani nerve during the passage of that nerve between the Pterygoid muscles. The chorda tympani, though at first having only a mechanical union, becomes intimately associated with the lingual.

The inferior dental and the gustatory nerves are united near their origin by a small filament.

The branches of the lingual are as follows:—

(1) A communicating branch with the hypoglossal. This nerve, according to Luschka, is recurrent in the sheath of the hypoglossal nerve. Its branches in part are distributed to the wall of the internal jugular vein, and in part to the sinuses and cancelli of the occipital bones, which are reached by the branches passing through the anterior condyloid foramen.

(2) A small branch to the palato-glossal fold, which passes also to the tonsil.

(3) Sublingual branches to the mucous membrane of the floor of the mouth and gum tissue.

(4) Lingual branches which pass between the longitudinal fibres of the tongue, and those of the Genio-hyo-glossus muscle. Those to the border of the tongue are joined at the level of the middle third of the Hyo-glossus muscle by a filament derived from the Mylo-hyoid muscle.

(5) Below, several branches are directed to the submaxillary gland.

The lingual, in addition, sends a few plexiform branches beneath the tongue, and some terminal branches to the mucous membrane about the under surface of the tip of the tongue and the glands of Nühn.

The Inferior Dental Nerve. This nerve is directed downward between the two Pterygoid muscles, and afterward between the lower jaw and the Internal Pterygoid. In the latter locality it is in association with the mylo-hyoid nerve. The nerve enters the dental canal by the posterior dental foramen, and passes along its entire length, giving filaments to the molar and bicuspid teeth. At the mental foramen, it divides into two sets of branches. By far the *larger set* effects exit through the mental foramen, where the branches are arranged in a plexiform fashion into two planes: one, the anterior, supplies the skin, the lip, and the inferior part of the cheek (fig. 1, Plate LXXXV.); the other, the posterior, crosses between the muscular layer and the glandular layer to terminate in part in the glands, and in part in the labial mucous membrane.—The *smaller set* is confined to a few delicate filaments which continue within the cancelli of the lower jaw, as far as the symphysis, to supply the canine and incisor teeth.

As the nerve escapes from the oval foramen, it gives off a *recurrent branch*. This passes through the spinous foramen in company with the middle meningeal artery, and runs backward to the middle cerebral fossa, dividing into an anterior and a posterior branch. The *anterior branch* enters one of several openings in the substance of the greater wing of the sphenoid bone; the *posterior branch* passes through the petro-squamous suture to the lining membrane of the mastoid cells.

THE GANGLIA OF THE FIFTH NERVE.

The fifth nerve is remarkable in possessing four ganglia. Each ganglion yields, in addition to its nerves of distribution, a motor or sensory, and a sympathetic filament. From the circumstance that these ganglia most probably form part of the sympathetic system, they are here treated separately and subordinated to the description of the fifth nerve. The names of the ganglia are as follows: the ophthalmic, spheno-palatine, otic, and submaxillary.

In addition to these, an inconstant collection of ganglionic matter may be met with beneath the infra-orbital foramen, and another within the anterior palatal foramen.

Ganglia of the Fifth Nerve { Ophthalmic. / Spheno-palatine. / Otic. / Submaxillary.

I. The Ophthalmic Ganglion.—The ophthalmic (lenticular) ganglion is a small flattened body (fig. 2, Plate LXXXIV.), lenticular, or more or less quadrangular in shape, and having a diameter of about one line. It is placed between the External Rectus muscle and the optic nerve, at about its posterior third, and lies generally in contact with the ophthalmic artery.

The branches of communication of this ganglion are as follows:—

1. The *motor branch* arises from the inferior division of the third cranial nerve. It is short and thick, and joins the ganglion at its posterior inferior angle. It is sometimes duplicated.

2. The *sensory branch* arises from the nasal nerve, while still retained in the cavernous sinus. It is long and slender, and joins the ganglion at its posterior superior angle. An occasional junction from a filament of the lachrymal nerve is described.

3. The *sympathetic branch* arises from the carotid plexus, and through that from the superior cervical ganglion. It may join the sensory filament instead of the ganglion.

The branches of distribution of the ophthalmic ganglion are the *short ciliary* nerves. They arise by two distinct bundles, each composed of six to eight filaments. Those from the anterior superior angle pass between the optic nerve and the Superior Rectus muscle. Those from the anterior inferior pass between the optic nerve and the Inferior Rectus muscle. They are joined by some filaments of the nasal nerve, pierce the sclerotic coat, and pass forward between it and the choroid coat as far as the iris, within which they are lost.

II. The Spheno-palatine Ganglion.—The spheno-palatine ganglion (ganglion of Meckel) (Plate LXXXIV.) is the largest of the ganglia of the fifth pair. It is situated in the pterygo-maxillary fossa, close to the spheno-palatine foramen, and is surrounded by fat. It is of a triangular shape, its posterior extremity being tapering, and composed of gray matter; its anterior extremity being broader, with little or no gray matter. The branches are as follows:—

1. The *orbital* branches. These delicate branches enter the orbit through the spheno-maxillary fissure, and are lost upon the periosteum. They reach the sphenoidal sinus, and supply the posterior ethmoidal cells by passing between the sphenoid and ethmoid bones.

Some of the branches of this ganglion are distributed to the neurilemma of the optic nerve (Arnold and Longet). Luschka describes among this group, under the name of the spheno-ethmoid branches, two or three filaments which pass through the spheno-maxillary fissure to ascend to the hinder part of the internal orbital wall, where they pass through the posterior ethmoidal foramen, and enter the brain case. Bock describes a branch of the *orbital* ascending to join the sixth nerve.

2. The *nasal* branches. These pass horizontally inward, and enter the nasal cavity through the spheno-palatine foramen. They consist of two branches. The *upper* nasal consists of several small nerves supplying the upper and posterior part of the septum, the mucous membrane covering the superior and middle nasal scrolls, and the posterior ethmoidal cells. The *larger* and more important division of the nasal branches (naso-palatine) crosses the roof of the nasal chamber, and is directed vertically downward, then horizontally forward along the nasal septum, to which, however, it gives no branch, nearly touches its fellow of the opposite side, and emerges from the nasal chamber to be distributed to the anterior portion of the hard palate through the incisorial or anterior palatine foramen. Within this foramen, the nerve of the right side is usually behind that of the left.

3. The descending *palatine* branches. These consist of three sets: the *large anterior palatine*, the *small posterior palatine*, and the small *external palatine* branches.

The *large anterior palatine* descends within the posterior palatine canal, to emerge thence through the posterior palatine foramen and to be distributed to the sides of the hard palate in company with the posterior palatine artery. Its branches lie in grooves of the hard palate, and extend nearly to the incisor teeth. The nerve supplies the gums, glands, and mucous membrane, and anastomoses in front with the naso-palatine nerves.

The nerve sends a small branch to the middle and lower turbinated bones. At about the same point with the foregoing, a filament from the hinder part of the trunk passes through a separate canal to the soft palate. The latter branches are, when well developed, described by most authors under the name of the *middle palatine* nerves.

The *small posterior palatine* enters the small posterior palatine canal, and is divided as follows: one set of filaments proceed to the Levator Palati and Azygos Uvulæ muscles; and another sensory set to the mucous membrane on the superior aspect of the soft palate and its glands. The nerve may be considered as constituting a descending branch of the great superficial petrosal, which, in turn, is a member of the facial group of filaments.

The *external* branches are very small. They pass between the superior maxilla and the External Pterygoid muscle, enter a small canal between the superior maxilla and the pterygoid process of the palatal bone, and are then distributed to the uvula, the tonsil, and the soft palate.

4. The *Vidian branch* (pterygoid branch). This nerve is continuous with the gray matter of the ganglion. It contains gray matter for some distance from its origin, which finally passes off as a distinct trunk, the *inferior* or *great deep petrosal nerve*, and is lost in the sympathetic network about the carotid artery. Sometimes it arises as a distinct branch from the spheno-palatine ganglion. The Vidian nerve extends directly backward, and, passing through the Vidian canal of the sphenoid bone, pierces the fibro-cartilage occupying the median lacerated foramen, within which the carotid branch is given off, and becomes the *great superficial petrosal nerve*. This is now directed outward, and passes beneath the ganglion of Gasser, from which it is separated by a delicate layer of the dura mater. It then passes to the anterior face of the petrous portion of the temporal bone, and enters the hiatus Fallopii to reach the facial nerve at the intumescentia gangliformis. This, the standard description, it is now believed, should be so modified as to read: that the nerve arises from the facial nerve, passes *toward* the spheno-palatine ganglion, and is continued thence to the palate as the *posterior palatine* nerve.

5. The *pharyngeal* branches. These are often described as branches of the Vidian nerve. They may, however, arise

EXPLANATION OF PLATE LXXXIII.

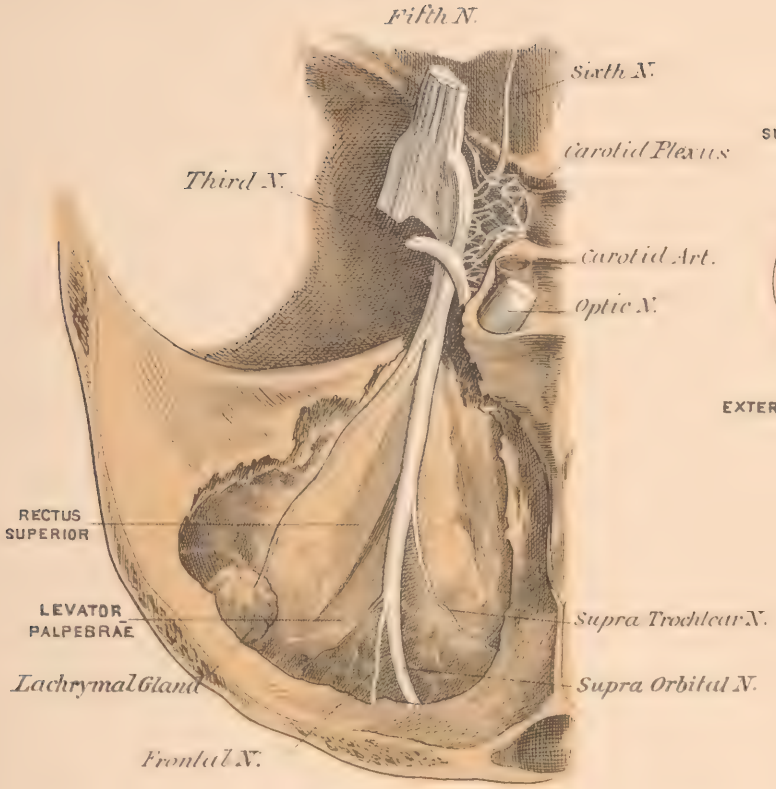
Fig. 1. The nerves displayed by dissection of the floor of the middle cerebral fossa and the orbit, after removal of the floor of the anterior cerebral fossa. The nerve going to the lachrymal gland is the lachrymal nerve.

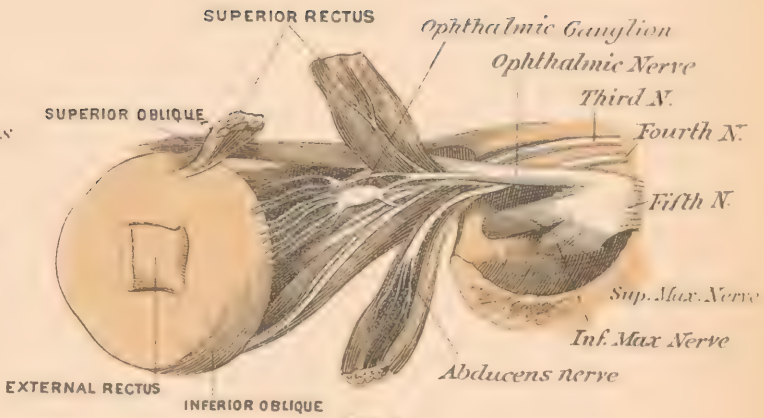
Fig. 2. A diagrammatic representation of the cervical portion of the spinal cord and the floor of the fourth ventricle. The apparent origins of the ninth, tenth, and eleventh cranial nerves, and those of the spinal nerves from the first to the fourth, are displayed.

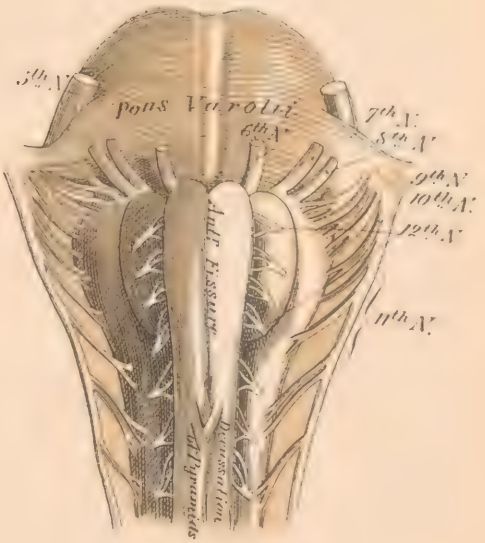
Fig. 3. The nerves of the orbit, including the division of the fifth nerve into its three great branches.

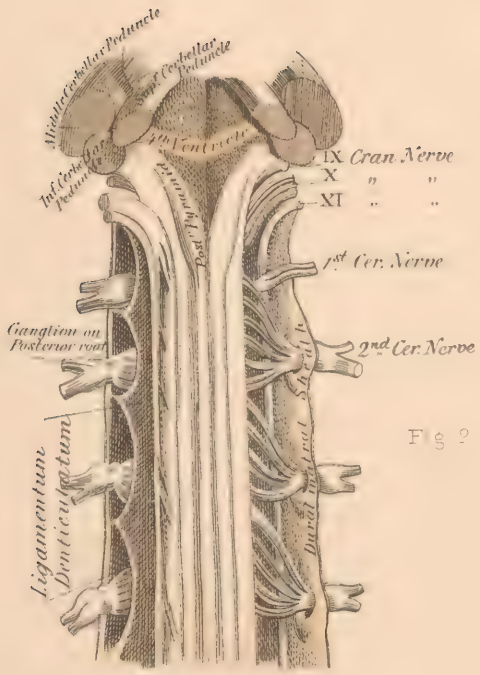
Fig. 4. The pons Varolii and the nerves arising from this part of the brain.

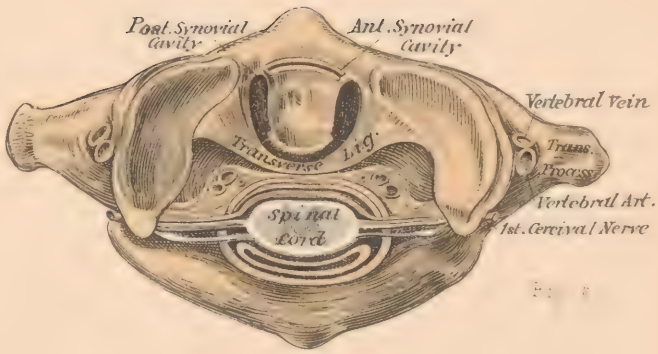
Fig. 5. The atlas, seen in position from above while in articulation with the axis.











T.S. nclair & Son Lith.

as distinct branches, and be placed within the pterygo-palatine canal, whence they appear on the lateral wall of the pharynx, about and behind the orifice of the Eustachian tube.

6. The *superior* branches. These are generally two in number, and serve to unite the trunk of the superior maxillary nerve to the ganglion. Many of the fibres pass directly through the gray matter of this structure to appear below as the descending palatine branches. Luschka would, therefore, describe the latter nerves not in relation to the ganglion, but as branches of the main nerve trunk.

III. The Otic Ganglion.—The otic ganglion (fig. 1, Plate LXXXIV.) is placed to the inner side of the inferior maxillary nerve, a little above the origin of the auriculo-temporal branch. Its external face answers to the point of union of the motor trunk with the sensory. Its inner surface lies beneath the cartilaginous portion of the Eustachian tube, and on the Tensor Palati muscle. Behind it is the middle meningeal artery. It is of a yellowish-gray color, and presents an ovoid shape, is flat, and of soft consistence.

Its branches of connection are as follows:—

1. Motor root (short), from the internal pterygoid nerve, where it pierces the ganglion.

2. Sensory root (long) from the lesser superficial petrosal nerve; which, in turn, is derived from the tympanic branch of the glosso-pharyngeal nerve within the temporal bone. A branch of this nerve joins the facial at the gangliform swelling.

3. Sympathetic, derived from the plexus about the middle meningeal artery.

4. A branch of union with the auricular branch of the auriculo-temporal nerve.

The otic ganglion sends branches to the Tensor Tympani and the Tensor Palati muscles; and sensory branches, two or three in number, reach the mucous lining of the middle ear.

IV. The Submaxillary Ganglion.—The submaxillary ganglion (Plate XCI.) is the most variable of the ganglia of the fifth pair. Commonly of a triangular shape, and rather thick, it may be plexiform or absent. It is situated between the outer side of the Hyo-Glossus muscle and the deep part of the submaxillary gland.

It presents (*a*) a short sensory root from the lingual; (*b*) a long motor root from the fibres continuous with the chorda tympani nerve; and (*c*) sympathetic filaments from the plexus about the facial artery.

It sends off numerous branches of distribution to the submaxillary glands and walls of the duct of Wharton, as well as some ascending branches to join filaments of the lingual, in a plexiform arrangement at the side of the tongue. No branches are given to muscles—a marked contrast to the manner of distribution of the branches of the otic ganglion.

The minute *blood-supply* of the apparent origin and the encranial portion of the trifacial is derived from one of the transverse arteries (Duret).

Variations of the Fifth Nerve not otherwise mentioned.—A twig from the front of the nerve has been known to supply the frontal sinus. The lachrymal nerve may unite with the superficial temporal branch of the inferior maxillary division through the skin of the temple. The naso-ciliary nerve may supply the lateral portion of the palpebral region. The orbital nerve may be absent, its place being taken by branches of the infra-orbital nerve. A branch may pass from the nerve while within the orbit, and pass outward over the infra-orbital border to the upper lip. The supra-trochlear nerve may pass through a foramen of the frontal bone.

In variations of the superior dental nerve a branch resulting from union of the anterior with the posterior superior dental nerve may supply the Buccinator and the Levator Anguli Oris muscles. The posterior dental nerve sometimes gives a branch to the External Pterygoid muscle.—The buccal nerve may arise directly from the Gasserian ganglion. It effects its exit from the skull by a distinct foramen, runs between the inferior surface of the great wing of the sphenoid bone and the upper border of the External Pterygoid muscle, and, reaching the anterior surface of the muscle, is there distributed in the usual manner. It may be given off from the superior maxillary nerve, and unite with the posterior dental. A branch of the buccal nerve sometimes arises from the inferior maxillary division of the great fifth pair, and unites with a branch arising from the superior division to form a loop around the internal maxillary artery. The External Pterygoid muscle may be supplied by the buccal nerve. The lingual nerve may give branches to the Internal Pterygoid muscle, and has been known not to go to the tongue, but to the occipital region. Meckel compares this branch to the posterior cutaneous branch of the pneumogastric nerve of fishes, and J. Müller to the auricular nerve. The mylo-hyoid nerve may supply the anterior belly of the Digastric muscle. A branch may join the gustatory branch on the distal side of the submaxillary salivary gland. The Inferior Dental nerve may pierce the outer lamina of the lower jaw, pass through the anterior border of the Masseter muscle, and unite with the facial nerve. The spheno-ethmoidal nerve is deemed a variation by Henle and Bankert, Smith and Phillips.[1] According to Luschka[2] it is constant.

Remarks.—The applications to practice of a knowledge of the anatomy of the fifth nerve are on the whole fewer in number than might be inferred from the extent of origin and distribution of the nerve. They relate (*a*) to the deep origin and intrinsic fibres; (*b*) to the encranial portion; (*c*) to the excranial portion.

(*a*) Notwithstanding the extensive course of the intrinsic nerve-fibres of the fifth nerve, but little is known concerning the effects of pressure upon them or of their degeneration.

[1] Guy's Hosp. Rep., xiv., 1869, 452.

[2] Archiv f. Anatomie, 1857, 313, fig.

(*b*) The main nerve-trunk and each of the three main divisions may be compressed by thickened nerve-sheaths, or by calcareous deposits.—In a case reported by F. H. Gross,[1] in which a trifacial neuralgia was cured by the ligation of the common carotid artery, it was plausibly conjectured by the recorder that pressure against the Gasserian ganglion had been maintained by a dilated internal carotid artery. Pressure on the nerve at the ganglion, as has been observed by Romberger,[2] in a case of aneurism of the terminal portion of the internal carotid artery, may cause in addition to the neuralgic pains destructive inflammation of the cornea with ophthalmia.—The nerve is the frequent seat of neuralgiæ, which are often exactly confined to surfaces answering to the distribution of the nerve. A case of neuroma is thus described by J. Althaus.[3] In a male aged forty-five, a tumor was situated on the left trifacial nerve. It was one inch in length, and of a pyramidal form, having its apex near the apparent origin of the nerve, and its base beneath the posterior clinoid process. The Gasserian ganglion and the encranial portions of the branches were enlarged and covered with firm, adherent dura mater. The progress of the case had been as follows: Anæsthesia of the left side of the face was first observed; later, paralysis of the muscles of mastication and loss of general sensation in the nasal chambers. Vision became impaired, and finally was lost. There was partial loss of power over the general muscular system, followed by death.—In a second case of involvement of the encranial portion, caused, it was thought, by rheumatic inflammation of the sheath of the nerve, the muscles elevating the lower jaw were paralyzed. It was interesting to note that the pterygoid muscles were more profoundly affected than the Masseter and the Temporal, which recovered while the function of the pterygoid muscles remained permanently impaired.[4] General sensibility was lost in the anterior two-thirds of the tongue, as a result of which the tongue was horribly misshapen and torn by the teeth.

S. Weir Mitchell[5] records an instance of a pistol-ball wound which had severed the third, fourth, and sixth nerves, and the ophthalmic branch of the fifth nerve. The ball had entered the right temple and, passing inward beneath the right optic nerve, had lodged in the ethmoid bone. The nerves were divided as they passed through the cavernous sinus. About half an ounce of blood was effused, and found its way upward and forward, so as to compress the olfactory bulb.

(*c*) In the excranial portion of the nerves the branches of each of the three divisions of the fifth nerve may be separately involved by injury or disease, or be divided by the knife of the surgeon.—Diseased action, as localized and defined by nerve distribution, can be observed in the distribution of vesicles in herpes frontalis.—The *supraorbital nerve* as it passes over the supraorbital arch, has been sought for and secured in the attempt to relieve spasm of the palpebral muscles. An incision one inch and a half in length made over the supraorbital notch will expose the region at which the nerve escapes from the orbit; and the nerve, being sought for with a blunt hook in the parts lying directly beneath the orbital roof, can be found and drawn forward for a distance sufficient to permit of division or the removal of a segment.—When the supraorbital nerve has been crushed or injured in such a way that it remains irritated, an inflammation or some other affection of the corresponding eye may supervene. A. Notta[1] has demonstrated that out of 128 cases of neuralgia of the fifth nerve, the eye was congested 34 times; and in most of those cases the nerve attacked was the supraorbital. Photophobia existed in 18 cases. In a case recorded by Vallez, there was a hyperæmia of one eye, with abundant mucous secretion, followed by an ulceration of the cornea, in a man who had received a deep wound of the face, dividing the superior maxillary nerve.

Division of the superior maxillary and inferior maxillary branches have been repeatedly essayed.[2] M. Vanzetti[3] has reported a case of neuralgia of five years' duration, of the left side of the tongue, in which a cure was effected by resection of the *lingual nerve*. An incision was made one inch and a half in length in the alveolo-lingual groove, extending from the last molar forward. The palato-glossal fold was divided, and the nerve exposed as it turned round the anterior border of the Internal Pterygoid muscle. A portion of the nerve a few lines in length was removed, whereupon the pain immediately ceased and did not return. In five cases, C. H. Moore[4] obtained relief from the severe pain accompanying cancer of the

[1] Am. Journ. Med. Sci., 1883, 366.

[2] Neuralgiæ Nervi Quinti Specimen, Berlin, 1840, fig.

[3] Med.-Chir. Trans., lii., 1869, 35. [4] Ibid., 27.

[5] Injuries of Nerves, 336.

[1] Archives de Médecine, iv. 5 ser. 1, 1854; see also W. Parker, N. Y. Journ. of Med., 3d ser. i., 1856, 198.

[2] For an analysis of the cases involving the superior maxillary division and the spheno-palatine ganglion, see P. S. Conner, Am. Journ. Med. Sci., lx., 1870, 359.

[3] Gaz. des Hôpitaux, Jan. 21, 1868.

[4] Proc. Med. and Chir. Soc., 1862, 11.

tongue, by dividing the *lingual nerve*. An incision was made in the soft structures on the inside of the ramus of the lower jaw immediately behind the last molar tooth, and extending three-fourths of an inch forward. The mucous membrane and a portion of the Mylo-hyoid muscle were divided. A curved knife was then employed to sever the nerve as it lay behind and beneath the beginning of the alveolar ridge. The tongue in each case became absolutely insensible on the side operated upon, from the palato-glossal fold forward. When, however, the disease invaded the area of distribution of the glosso-pharyngeal nerve, the pain returned. It has been found by M. Holl[1] that the *buccal nerve* can be reached through the open mouth by incising the mucous membrane in the groove directly in front of the anterior border of the Masseter muscle.

Each of the facial branches, viz., the supra-orbital, the infra-orbital, and the mental pass through osseous foramina before terminating. Hyrtl has pointed out the fact that these nerves are more liable to neuralgia than are others of the fifth nerve, and explains it by the increased liability incurred to pressure from osteophytes or to rheumatic inflammation of the sheaths as they lie in the narrowed openings.

Vanetti[2] reports that, if the lingual nerve be cut in operation, the anterior part of the tongue of the corresponding side may lose gustatory power.

Other muscles supplied by the motor portion of the fifth nerve are the Mylo-hyoid, the anterior belly of the Digastricus, the Tensor Palati, and the Tensor Tympani. As regards the three first named, no morbid symptom can be discovered in paralysis of the fifth nerve. The position and function of the soft palate are in no way altered, which is probably due to the circumstance that the Tensor Palati receives nervous fibres, not only from the motor portion of the fifth nerve, but also from the pneumogastric and the spinal accessory nerves.[3]

When the notch is present, the finger drawn along the supraorbital arch can detect the point of escape of the supraorbital nerve. But when the notch is converted into a canal, the finger can no longer determine it.

THE ABDUCENS, OR THE SIXTH NERVE.

The Abducens, or the Sixth Nerve, is the motor nerve of the External Rectus muscle. It arises from a *nucleus* in common with the lower nucleus of the seventh nerve, at the floor of the fourth ventricle, beneath the fasciculus teres, and immediately in advance of the medullary striæ. To the outer side lies the main auditory nucleus. The intrinsic fibres escape from the nucleus to the median side, pass forward, going through the fibres of the trapezium on the way, and are continued upward from the anterior pyramid.

The *apparent* origin is at a point between the anterior pyramid and the pons Varolii. The *encranial portion* of the nerve passes directly forward, is crossed by the transverse and auditory arteries, and pierces the dura mater to enter the cavernous sinus a little to the median side of the fifth nerve or behind it. Within this space the nerve lies in the outer and lower part of the sinus, to the outer side of the internal carotid artery, and is separated from the other contents by the lining membrane. The nerve enters the orbit through the anterior lacerated foramen, and passes between the two heads of the External Rectus muscle, to whose inner (ocular) surface its terminal filaments are distributed.

The abducens sends a branch to the sympathetic plexus about the internal carotid artery.—While in the anterior lacerated foramen the nerve lies above the ophthalmic vein, or between the two veins of this name, if such be present. It lies beneath all the other nerves of the orbit at this point. —In the cavernous sinus the nerve lies directly over a bony prominence in an axial line with the petrous ridge.

Variations.—W. Krause found the abducens at its apparent origin composed of three roots, a short distance in advance of the posterior border of the pons.—The trunk may unite through a small branch with the ophthalmic or inferior maxillary division of the fifth nerve. A branch has been seen by Petit joining the long ciliary nerve.—In a case recorded by Generali,[1] the sixth nerve was absent on the left side, and its place taken by the third nerve. A similar instance has been noted by Faesbeck.[2]—The nerve may send a branch to the spheno-palatine ganglion.—According to Adamück,[3] a filament from the abducens may be distributed to the iris. Hence the fixation and the dilatation of the pupil in paralysis of the third nerve may be subject to infrequent variation.—In mammals, generally, the sixth nerve has a wider range of distribution than in man, since it supplies the suspensory muscles of the eyeball and the muscle of the nictitating membrane.—Notwithstanding the fact, that the facial and the abducens have a common medullary origin, no compensation occurs between the distribution of the two nerves.

Remarks.—The abducens nerve, when paralyzed, causes paralysis of the External Rectus muscle, a condition which may have a central or a peripheral

[1] Centralblatt für Chirurgie, No. 38.
[2] Loc. cit. [3] J. Althaus, Med. Chir. Trans., lii. 35.

[1] Omodei Annali Universali, 1842.
[2] Archiv für Anat. und Phys., 1842, 474.
[3] Centralblatt. Med. Wissenschaft., 1870, 657.

origin. When central, it may be associated with paralysis of the facial (see below). The nerve may be subjected to pressure in its encranial portion, especially as it passes over the pons and enters the cavernous sinus. As a result of physiological observation, it is found that the nerve is the best example of a motor nerve of all of the cranial series. According to Valentin, it is the only member of the ocular group the section of which fails to elicit evidences of pain.

Additional Remarks on the third, fourth, sixth, and seventh nerves.—It has been seen in the preceding descriptions that the third, fourth, sixth, and seventh nerves form a group of nerves which are closely associated. A synergetic action is observed in the movements of the eyeballs and the eyelids both in the waking and sleeping states that depends upon the harmonious relations of these nerves. The facial and third nerves antagonize in the upper eyelid; the third and sixth nerves of opposite sides of the body act together in looking to the right or to the left; as do the third and fourth nerves in the upper and lower rotating acts of the eyeball, etc.—The quadrigeminal mass, with the aid of the posterior longitudinal fasciculus, is the centre of a complex reflex mechanism, whose afferent tracts lie in the optic and ophthalmic nerves, and whose efferent tracts lie in the third, fourth, and sixth nerves, and, in part, in the seventh. The cerebellum aids in the control of these coördinations, since mutilation of this organ is followed by nystagmus, by disturbances of the action of the iris, and by facial paralysis.—E. C. Spitzka endeavors to connect the distribution of the seventh nerve to the Orbicularis Palpebrarum by restricting to this muscle those fibres of the seventh nerve which arise from the nucleus in common with it and the sixth nerve. But thus far no clinical evidence has been deduced in support of this view. In the only case known to the writer—one reported by W. W. Keen[1]—in which there was associated symmetrical paralysis of the sixth and facial nerves, occurring congenitally in a male child, the paralysis was complete for the sixth nerve, while a general paresis existed in the entire distribution of the seventh nerve, instead of being restricted to the Orbicularis Palpebrarum. According to W. R. Gowers,[2] the common nucleus for the abducens and facial nerves, as described in the text, may be degenerated, while the fibres of the facial nerve passing over the nucleus remain unchanged.

[1] Trans. College of Physicians of Phila., 1883, 434.

[2] Centralblatt für die Med. Wissenschaft., Berlin, 1878, 417.

It is evident that a clot of blood involving the inferior facial nucleus, common nucleus, and the adjacent reticular formation could easily cause paralysis of central origin.

THE FACIAL, OR THE SEVENTH NERVE.

The Facial or the Seventh Nerve is for the most part a motor nerve, and supplies the muscles of expression. In addition it supplies the muscles of the auricle, the Stapedius, Levator Palati, Azygos Uvulæ, Stylo-Hyoid, Buccinator, and Platysma Myoides muscles; the posterior belly of the Digastric muscle; and in some individuals the Stylo-Pharyngeus, Stylo-Glossus, and Palato-Glossus muscles. It unites through the chorda tympani with the fifth nerve, and by separate branches with the glosso-pharyngeal, and with the pneumogastric nerve. It thus serves as a great nerve of communication between the anterior and the posterior sets of cranial nerves.

The facial nerve secures its true origin from a nucleus in common with the sixth nerve, and from a nucleus (inferior facial nucleus) lodged in the pons above the superior olive between the intrinsic fibres of the sixth and seventh nerves. The *intrinsic fibres* arise from the dorsal surface of the nucleus, and pass obliquely upward to the fasciculus teres near the median line. They then turn abruptly outward over the abducens and facial nucleus, receive accessions from the nucleus at its outer side, and, passing obliquely downward and outward, become apparent at the side of the medulla, between the olivary and restiform bodies, and between the sixth and eighth nerves. This complex arrangement is called the *facial loop*, the fibres passing dorsally uniting with those passing ventrally to form the two sides of a loop, the curve of which is filled in by the common nucleus, while the facial fibres pass over it.

The *apparent origin* is seen in the groove between the olivary and restiform bodies, directly back of the pons.

The *encranial portion* of the facial nerve passes forward and outward in a horizontal direction between the pons and the middle peduncle of the cerebellum, and then around the lower border of the peduncles, against which it is closely applied, to gain the internal auditory meatus within which it passes in company with the auditory nerve. The nerve here lies within a concavity upon the upper side of the auditory nerve, but leaves it at the base of this passage to enter the facial canal and aqueduct of Fallopius. The nerve is soon abruptly deflected downward in the substance of

the internal wall of the cavity of the tympanum above the oval window and behind the pyramid to emerge from the cranium at the stylo-mastoid foramen. While within the internal auditory meatus the nerve is in close association with a small nerve, the *pars intermedia* (nerve of Wrisberg). This filament is of obscure origin, but is usually described in connection with the facial nerve. This nerve is connected both with the auditory and facial nerves, and may end in the former.[1]

The *excranial portion* of the nerve is turned forward, and abruptly divides into branches which supply the muscles of expression, the muscles of the auricle, the Stylo-Hyoid muscle, the posterior belly of the Digastric muscle, and the post-auricular space. Secretory branches are also sent to the parotid and submaxillary glands.

The branches of the Facial Nerve may be thus displayed:—

- Before escaping at the stylo-mastoid foramen.
  - Stapedius.
  - Chorda tympani.
  - Connecting branch with pneumogastric.
  - " " " glosso-pharyngeal.
- After escaping from the stylo-mastoid foramen.
  - Post-auricular
    - Auricular.
    - Occipital.
  - Stylo-hyoid.
  - Digastric.
  - Stylo-glossal.
  - Temporo-facial
    - Temporal.
    - Malar.
    - Infra-orbital.
  - Cervico-facial
    - Buccal.
    - Supra-maxillary.
    - Cervical.

The nerve before escaping at the stylo-mastoid foramen.—As it is deflected from the horizontal to the vertical position, the nerve presents a ganglion, named from its position the geniculate ganglion, placed about two lines from the end of the facial canal. The geniculate ganglion is remarkable for not involving all the fibres of the facial, and for receiving the terminal fibres of the *pars intermedia*. Before entering the ganglion the facial nerve gives off two branches.

The *stapedius* nerve. This, the most slender of the branches of the facial, arises from the trunk opposite the pyramid, enters a particular canal, and is directed to the Stapedius muscle, within which it is lost.

The *chorda tympani*. This nerve arises from the main trunk behind the ganglion, but presents an apparent origin near the exit of the nerve, a short distance above the stylo-mastoid foramen. From this latter point it ascends, and enters a special canal, along which it is conducted to the back part of the tympanum below the end of the pyramid where it lies close to the membrana tympani. It thence passes between the long handle of the malleus and the vertical process of the incus, and escapes from the tympanum through a special opening near the glenoid fissure. Pursuing its course downward and forward under the External Pterygoid muscle, it finally joins the lingual nerve, besides sending several filaments to the submaxillary salivary gland.—H. R. Bigelow[1] believes that the chorda tympani is a continuation of the nerve of Wrisberg. He assigns to it the function of presiding over taste at the anterior two-thirds of the tongue. According to J. Sapolini,[2] the chorda tympani is an independent cranial nerve, and is entitled to distinct rank as the thirteenth cranial nerve.

The *connecting branch with the pneumogastric* leaves the facial nerve at about the level of the chorda tympani.

The *connecting branch with the glosso-pharyngeal nerve* arises from the trunk immediately at the stylo-mastoid foramen, and joins the glosso-pharyngeal below the petrosal ganglion.

The nerve after escaping from the stylo-mastoid foramen.—The nerve, as it passes out from the stylo-mastoid foramen, immediately prior to its effecting the terminal division, gives off the post-auricular, stylo-hyoid, digastric, and stylo-glossal nerve.

The *post-auricular nerve* passes backward along the outer margin of the posterior belly of the Digastric muscle, beneath the mastoid process, and is closely held thereto by dense fibrous tissue. It soon divides into two branches: an *auricular branch*, which ascends to pierce the Retrahens Aurem muscle, and is finally lost within the Attolens Aurem, after sending some branches to the skin of the auricle; and an *occipital branch*, which is directed close to the bone along the course of the superior semicircular line, and supplies the occipital portion of the Occipito Frontalis muscle. The posterior auricular nerve anastomoses with the great auricular and the occipital nerves.

The *stylo-hyoid* nerve is a slender branch which, as the name expresses, supplies the Stylo-Hyoid muscle. It also anastomoses with a branch of the sympathetic upon the external carotid.

[1] See Chorda Tympani.

[1] Brain, 1880, iii. p. 43; also Archives of Med., New York, 1879.

[2] Ann. univ. di med. e chir., 1881, cclv. 3, Milan, 1881; also Am. Journ. Otology, iii., 1881, p. 312, for translation in part of Sapolini's article, and Phila. Med. Times, xiii., 1883, p. 361, for remarks by C. H. Burnett.

The *digastric* nerve arises from the same trunk as the preceding. It anastomoses within the posterior belly of the Digastric with the glosso-pharyngeal nerve, and, according to some writers, with the spinal accessory and pneumogastric nerves.

The *stylo-glossal* nerve (lingual nerve of Hirschfeldt) is a small branch which arises from the main trunk behind the styloid process. It supplies the Stylo-Glossus muscle, and, passing between the tonsil and the palato-glossal fold, it reaches the mucous membrane of the base of the tongue beneath which it is lost.

The *temporo-facial* division of the nerve passes through the parotid gland, and crosses the neck of the lower jaw, at about which point it effects a division into branches of unequal size, termed the temporal, malar, and infra-orbital. Among the branches of origin of these nerves an irregular network is formed known as the *pes anserinus*.

The *temporal* branch ascends nearly vertically, crosses the zygoma at a right angle, lies beneath the skin and temporal aponeurosis, and is distributed to the region of the temple and side of the forehead, the latter branches being the more voluminous, and lost for the most part within the frontal portion of the Occipito-Frontalis muscle. It anastomoses near its origin with one or two branches of the auriculo-temporal nerve, and at its terminal portion with branches of the supraorbital nerve. It gives, in addition, branches to the Attrahens Aurem and Attolens Aurem muscles, as well as to the Orbicularis Palpebrarum and Corrugator Supercilii.

The *malar* (ocular) branch passes forward across the malar bone to a point opposite the lower portion of the Orbicularis Palpebrarum to supply the lower eyelid, and to anastomose with the infraorbital branches, and with the malar branches of the superior maxillary branch of the fifth. The *transverse* (infra-orbital) branches extend parallel to the transverse facial artery across the Masseter muscle to supply the muscles of expression above the mouth. It divides into two sets of branches, a superficial and a deep. The *superficial* set is composed of numerous branches which supply the Zygomatic muscles, Levator Labii Superioris Alæque Nasi, and the small nasal muscles. The nerves of the *deep* set form the terminal filaments of the infraorbital nerve, and assist in forming the infraorbital plexus. They supply the Levator Anguli Oris and the Buccinator muscles.

The *buccal* nerve is directed across the Masseter muscle, between it and the parotid gland, and is distributed to the Buccinator muscle and the angle of the mouth. It anastomoses with the buccal (buccinator) branch of the inferior maxillary division of the fifth nerve, and with branches of the cervico-facial division. It yields, according to Cruveilhier, several small filaments to the Masseter muscle.

The *cervico-facial* division is smaller than the temporo-facial. It passes obliquely downward through the substance of the parotid gland to the angle of the lower jaw, where it divides into three terminal branches, the buccal, the supramaxillary, and the cervical nerves.

The *supramaxillary* nerves, often two in number, pass forward in the direction of the horizontal ramus of the jaw.

The *cervical nerve* (inframaxillary nerve) perforates the deep cervical fascia and divides into slender branches, which form arches beneath the Platysma Myoides upon the chin and beneath it to a point near the hyoid bone. It anastomoses by a descending branch with the superficial cervical plexus beneath the Platysma; some of its fibres supply that muscle, and others pierce it to supply the integument.[1]

The Branches of the Geniculate Ganglion are six in number.

Great Superficial Petrosal Nerve.
Lesser Superficial Petrosal Nerve.
Branches to the Sympathetic System.
Branches to the Tympanic Plexus.
Branch to the Pneumogastric Nerve.
Branch to the Glosso-Pharyngeal Nerve.

The *Great Superficial Petrosal Nerve*. This, the largest branch of the ganglion, is directed upward and outward, and, escaping from the tympanic cavity, joins the Vidian nerve at the hiatus Fallopii, and sends a filament to the carotid plexus.

[1] The question as to the degree in which the nerves of the cervical plexus supply the Platysma has been the subject of investigation by Bardeleben, Jenaisch. Gesellsch., 1879, 128. He finds the innervation of the muscle to be invariably derived from the facial nerve.

EXPLANATION OF PLATE LXXXIV.

Fig. 1. A dissection exhibiting specially the spheno-palatine and otic ganglia, the olfactory, and the glosso-pharyngeal nerves.

Fig. 2. A dissection exhibiting specially the fifth and pneumogastric nerves.

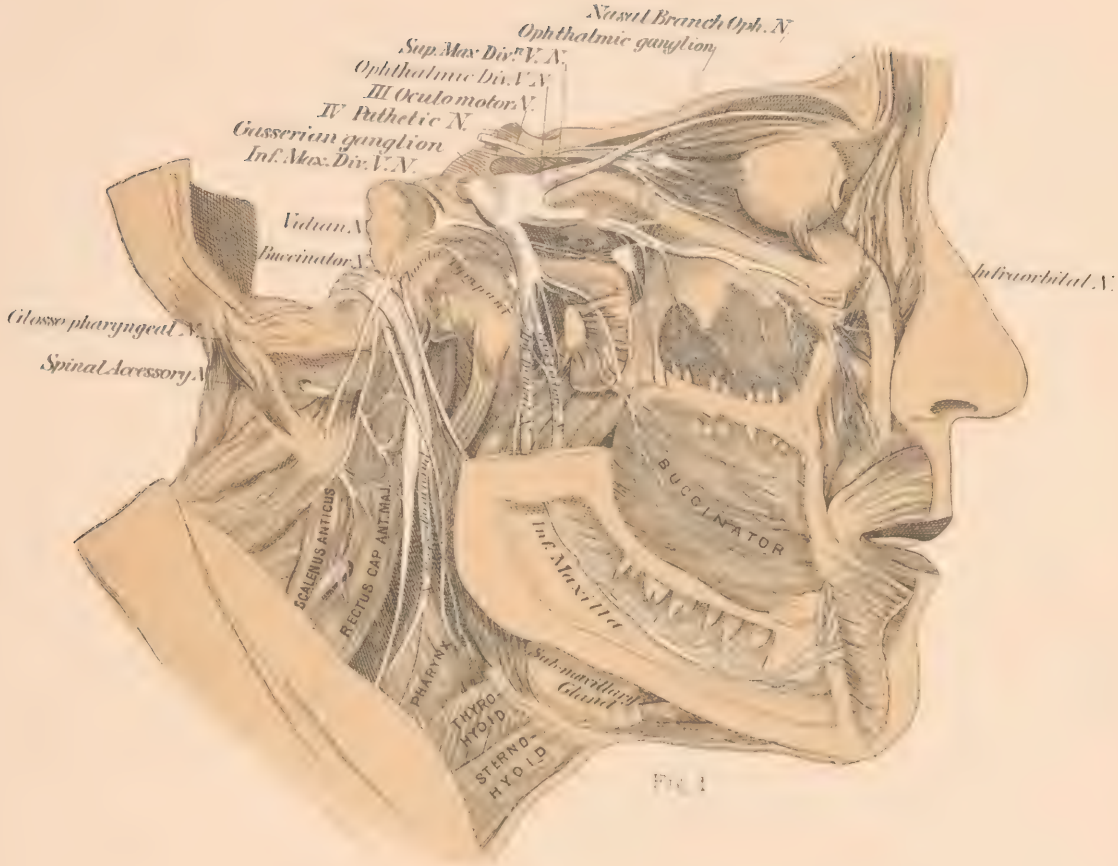


Fig. 1

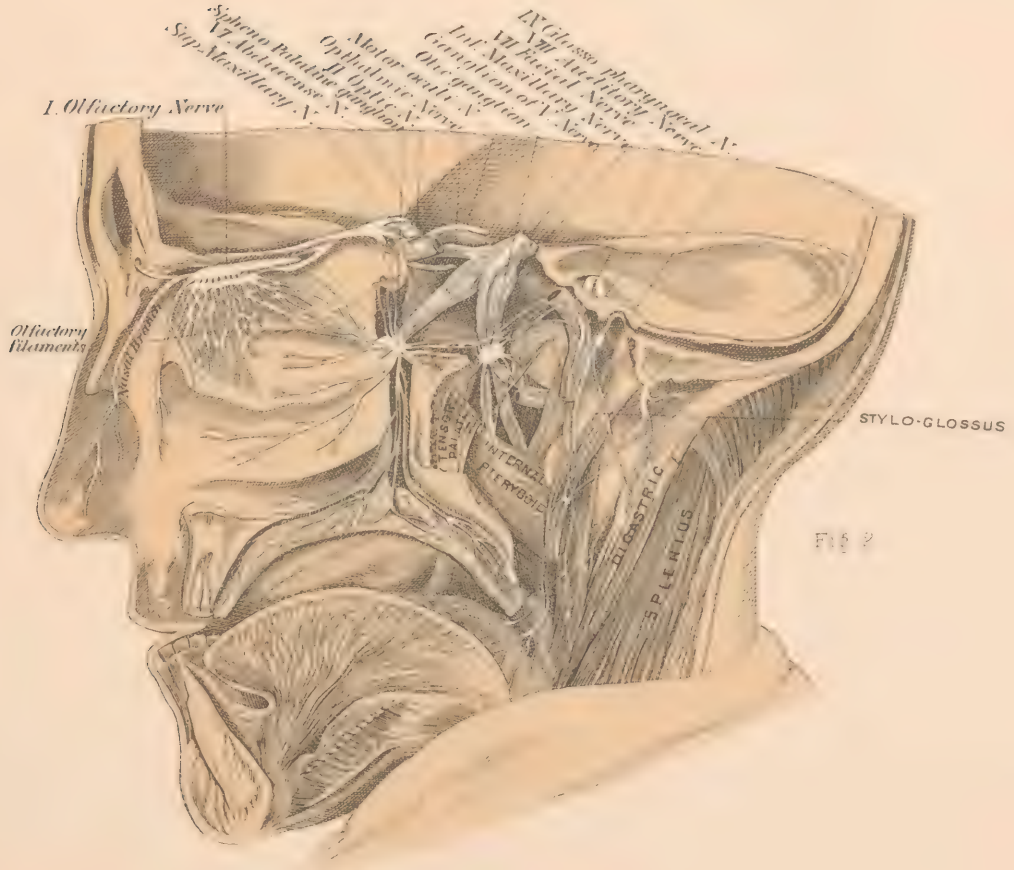


Fig. 2

T. Sinclair & Son, Lith.

The *Lesser Superficial Petrosal Nerve* is directed forward, and, uniting with a branch of the nerve of Jacobson, pierces the anterior wall of the tympanic cavity, to join the otic ganglion.

Branch to the Sympathetic System. A small filament under the name of the *external superficial petrosal nerve* joins the sympathetic branches about the middle meningeal artery.

Branch to the Tympanic Plexus. A small communicating branch joins the tympanic plexus.

The Branch to the Pneumogastric Nerve is described on p. 529.

The Branch to the Glosso-Pharyngeal Nerve is described on p. 529.

The *bloodvessels* of the encranial portion of the facial nerve are derived from twigs of the vertebral artery (Duret).

Variations.—The facial nerve is not subject to many variations. The nerve, in its relations within the skull and the pharynx, is less constant than in its relations upon the face and neck. The nerve was found by Beck,[1] in the dissection of a deaf mute, to be intimately united with the auditory nerve in the internal auditory meatus. The intermediate portion of the left facial nerve in this subject was large and divided into two portions, one of which joined the facial and the other the auditory nerve.—The *chorda tympani* may join the tympanic plexus by a small filament. Ascending fibres of the chorda tympani at its origin may join the trunk of the facial nerve. In a case reported by Erb,[2] in which the sense of taste was lost over the region of the right side of the anterior two-thirds of the tongue, the chorda tympani was found to be a branch of the superior maxillary division of the fifth nerve. Cruveilhier mentions a specimen in which the lingual branch of the glosso-pharyngeal nerve was absent, and in which its place was supplied by a branch from the facial nerve. The same interchange may take place between the two nerves upon the side of the naso-pharynx. The branch of communication with the pneumogastric nerve may be absent. The Stylo-Pharyngeus and the Stylo-Glossus muscles may be supplied by the facial.

The nerve, as it passes through the middle ear, may be separated from the mucous membrane by fibrous tissue only. The great superficial petrosal nerve is described by Rosenthal[3] as arising from the intumescentia gangliformis, and as sending motor branches to the soft palate. It is often described as a branch of the fifth nerve. Infrequently, a branch of the facial may descend in the Sterno-Cleido-Mastoideus muscle as far as its middle.

[1] Anat. Untersuch. über d. vii. u. ix. Nerven, Heidelberg, 1847, 67.

[2] Neurol. Centralblatt, 1882, 4.

[3] Diseases of the Nervous System, ii. 205.

Remarks.—The clinical applications of a knowledge of the facial nerve embrace—

(*a*) Central lesions; (*b*) Peripheral lesions.

(*a*) The central lesions occur as a result of involvement of the nuclei or of the intrinsic fibres.—When all the muscles of expression of one side are paralyzed, and hemiplegia of the opposite side exists, involvement of the medullary nucleus or of the medullary intrinsic fibres may be inferred.—When the facial paralysis is confined to the muscles moving the angle of the mouth and the lips, and is accompanied with hemiplegia of the same side, the nucleus and the fibres of the facial nerve are intact, and a lesion is known to exist in the crura cerebri and the medullary matter at the base of the corona radiata. No anatomical connection is known to exist between the site of this lesion and the facial nerve.—Facial and lingual paralysis may be associated with lesion of the inferior third of the precentral cerebral convolution.

(*b*) The peripheral lesions occur in three places: in the encranial portion, *i. e.*, between the apparent origin and the entrance of the nerve into the internal auditory meatus; as the nerve passes through the temporal bone; and after the nerve escapes from the temporal bone at the stylo-mastoid foramen.

The encranial portion.—In a case of occlusion of the left vertebral artery by an embolus, and of occupancy of the basilar and posterior cerebellar arteries by a clot, H. Hallopeau[1] observed the branches of the basilar artery supplying the nucleus of the seventh nerve to be also obliterated, and the facial nerve palsied. The fact that the arachnoid membrane passes around the nerve in the short internal auditory meatus should be a sufficient reason, for clinical purposes, to consider the nerve as it lies within this canal as subject to the effects of basal pressure. The nerve here may be pressed upon by sarcomatous tumors.—F. Schultze[2] records an instance of an aneurism of the size of a cherry occurring in the left vertebral artery of a phthisical subject, associated with convulsions of the left side of the face, of one year's standing. The patient, a male of fifty-six, had suffered for ten years from cerebral symptoms of an obscure character. The aneurismal tumor was found lying over the facial nerve, just prior to the entrance of the nerve into the internal auditory meatus. The auditory nerve was not involved.

The nerve as it passes through the temporal bone.—Frequent injuries to the trunk of the facial nerve as

[1] Arch. de Phys. norm. et pathol., 1876, 798.

[2] Virchow's Archiv, 1875, 385, fig.

it passes through the facial canal have been observed; fracture of the base of the skull, and necrosis of the temporal bone, are conspicuous among the causes. W. Moran[1] reports a case of facial palsy following upon an escape of blood into the Fallopian canal.

The anastomoses of the facial nerve within the temporal bone are numerous. They include union with the auditory, pneumogastric, glosso-pharyngeal, trifacial, and sympathetic nerves. It is evident that the typical expression of facial palsy is obtained in the lesion of the nerve, prior to its connection with any other nerve. —The importance of the union with the *pneumogastric*, *glosso-pharyngeal*, *auditory*, and *sympathetic nerves* is not determinable by clinical tests. It is more definite in the case of the union with the *fifth nerve*. This union is secured through three nerves, the *great superficial petrosal* uniting it with the sphenopalatine ganglion, the *lesser petrosal* uniting it with the otic, and the *chorda tympani* uniting it with the lingual branch of the fifth, and with the submaxillary ganglion.—According to Rosenthal,[2] pressure on the nerve in the Fallopian canal above the ganglion is often followed by deviation of the uvula and palate towards the paralyzed side. In lesions of the *great superficial petrosal*, there is obliquity of the uvula and the pillars of the palate; but simple deviation of the uvula, especially when the latter is long and touches the base of the tongue, is often observed in health.

Paralysis of the muscles of the soft palate, following some disease, as diphtheria, may be attributed either to the loss of power in the filaments of the facial nerve to these muscles through the medium of the great superficial petrosal nerve, especially those to the Levator Palati, or to the influence exerted indirectly upon this muscle by interference with the innervation of the glosso-pharyngeal twigs. The Levator Palati is the most important of all the pharyngeal muscles supplied by the facial nerve. The obliteration of the salpingo-palatal fold, and the subsequent depression of the velum are the most constant signs of facial paralysis as it affects the palate, and should be sought for in all conditions in which facial paresis is suspected. That these are not characteristic arises from the fact that these muscles are subject to atonic asymmetry of peripheral origin, when the facial nerve is in a normal condition, and from the fact that the range of variation of the distribution of the pharyngeal branches of the facial nerve is unknown.—Of the clinical significance of the union of the facial with the *otic ganglion* nothing is known. —Palsy of the main trunk above the origin of the *chorda tympani* has been known to occasion either a partial loss of, or a disturbance of, the sense of taste, an acid or metallic taste in the mouth being complained of, in the corresponding half of the tongue. This result is thought to be due to the suspension of the motor control exercised by the chorda tympani upon the bloodvessels of the tongue, through the agency of the submaxillary ganglion (see Variations). —The chorda tympani, as it crosses the tympanic membrane, becomes necessarily involved in some of the numerous lesions of this structure. Hence, partial loss of taste may be associated with deafness on the corresponding side.

The Stapedius muscle, receiving, as it does, a branch from the facial nerve, causes the mechanism of the ossicles to suffer impairment in facial paralysis, as is shown by the lessening of the hearing distance, and by the frequent occurrence of hyperæsthesia[1] of the auditory nerve, and of subjective noises.

The nerve after its escape from the stylo-mastoid foramen.—Facial paralysis is evidenced not only by loss of tonicity in the muscles of expression, and in the muscles about the nostrils, but the Stylo-Hyoid and Digastric muscles are also involved. The absence of clinical evidence on the subject is probably due to the fact that since the cervical plexus remains unimpaired, the muscular mechanism of the parts lying beneath the lower jaw and about the hyoid bone remains reasonably efficient.—The nerve in the child during parturition may be compressed immediately in front of the ear by the obstetric forceps.

In all obscure states of the terminal branches of the facial nerve, the distributions of the palpebral, oral, and cervical fibres should be carefully studied. S. Weir Mitchell[2] found the Orbicularis Oris and Buccinator muscles to respond to electrical stimuli, when in all the remaining muscles of the face contractility was lost.

THE AUDITORY, OR THE EIGHTH NERVE.

The Auditory Nerve, or the Eighth Nerve, is the nerve of hearing. It arises from three *nuclei:* first, a *main nucleus*, which lies in the medullary portion of the floor of the fourth ventricle beneath and behind the *striæ acousticæ*, and to the lateral aspect of the calamus scriptorius; this nucleus can be traced to the caput of the posterior horn of gray matter of the spinal cord; second, the *lateral nucleus*, which lies between the main nucleus and the restiform body;

[1] Trans. Path. Soc. Lond., 1868, 421.
[2] Diseases of the Nervous System, ii. 179.

[1] Lucas, Berl. med. Gesellsch., I. 1866.
[2] Injuries of Nerves, 332.

this nucleus is a subdivision of the main nucleus, and is by some writers included within it; third, the *accessory acoustic nucleus*, which lies between the restiform body and the anterior root of the nerve. The intermediary nerve most likely arises from this nucleus.

According to Meynert, the eighth nerve derives intrinsic fibres of origin from the cerebellum at the nucleus dentatus and nucleus fastigii.

The *intrinsic fibres* of the auditory nerve form two roots, the anterior and posterior. The *anterior root* arises from the dorsal aspect of the main nucleus, and forming the transverse lines of the floor of the fourth ventricle (*striæ acousticæ*), passes outward and round the inferior cerebellar peduncle to join the posterior root below the accessory nucleus. The posterior root arises from the ventral aspect of the anterior nucleus, and passes downward and outward, passing through the ascending root of the fifth nerve. A group of cells lies among the fibres of the anterior root to the outer side of the accessory nucleus.[1]

The nerve becomes *apparent*, as already mentioned, between the olivary and restiform bodies in company with the seventh. It passes outward and a little forward, in company with the facial nerve, and enters the internal auditory meatus; while within the meatus it sends to the facial a small branch known as the intermediary nerve. The auditory nerve terminates at the bottom of the meatus by dividing into branches to supply the labyrinth. For the details of this distribution, the reader is referred to the description of the Ear.

The nerve at its apparent origin is supplied by twigs from the vertebral artery.

Variations.—Fleishmann reports an instance of two gangliform enlargements of the cochlear branch of the auditory nerve.—The nerve, as it lies in the internal auditory meatus, may completely embrace the vestibular branch and the trunk of the facial nerve.

Remarks.—The clinical remarks on the auditory nerve come under three heads: (*a*) the nuclei and the intrinsic fibres; (*b*) the portion lying between the apparent origin and the base of the internal auditory meatus; (*c*) the terminal portion of the nerve in the labyrinth.

(*a*) Diseases involving the medulla oblongata may be accompanied by destructive pressure upon the nuclei and intrinsic fibres of the auditory nerve, with consequent deafness and vertigo.

[1] The nomenclature of the nuclei and of the intrinsic fibres of the auditory nerve is in a confused state. The statements in the text are based upon those of Schwalbe, Neurologie, 665.

(*b*) The auditory nerve is more frequently the seat of fibrous and sarcomatous growths than any of the cranial nerves. The temporal bone is either involved in the mass and affected by caries, or it is eroded, though it may remain unimpaired. Geo. P. Field[1] reports an instance of a sarcomatous growth originating from the walls of the internal auditory meatus, and compressing the auditory nerve. Similar cases are referred to on page 105. The facial nerve is apt to be involved.

(*c*) Baratoux[2] found, in an autopsy of a deaf mute, the auditory nerve in a state of parenchymatous inflammation, and the cells of the ganglion situated upon the circumference of the cochlear nerve degenerated; the cerebellar branch was intact.

THE GLOSSO-PHARYNGEAL, OR THE NINTH NERVE.

The Glosso-Pharyngeal, or the Ninth Nerve, is a sensory nerve to the pharynx, to the lining membrane of the middle ear, to the superior laryngeal aperture, and to the basal third of the tongue. It is a motor nerve to the Stylo-Pharyngeus muscle. It effects communication with the otic ganglion, with the facial and the pneumogastric nerves, and with the sympathetic nerve of the neck.

The nerve has a true origin from a *nucleus* which in part lies beneath the nucleus of the posterior auditory root, and which in part lies exposed on the floor of the fourth ventricle, in front of the nucleus (with which it is continuous) of the pneumogastric nerve. It also receives an accession from the trineural fasciculus.

The *intrinsic fibres* of the nerve pass obliquely downward and outward, and secure an *apparent origin* from the groove between the olivary and restiform bodies, in front of the fibres of apparent origin of the pneumogastric nerve, and behind those of the auditory nerve. The filaments are from five to six in number, and are arranged in two bundles, a large anterior and a small posterior bundle. The *encranial* portion of the nerve passes forward and outward, beneath and in front of the flocculus, and escapes from the cranium through the posterior lacerated foramen, in company with the pneumogastric and spinal accessory nerves, but placed in advance of these trunks, close to the temporal bone, and separated from them by a distinct fold of dura mater.

The nerve is a slender rounded cord which passes downward and forward between the internal and external carotid arteries, or between the internal carotid

[1] Lancet, ii. 1877, 840.

[2] Ann. des Maladies de l'Oreille, July, 1881.

artery and the internal jugular vein, following the general course of the Stylo-Pharyngeus muscle. Lying along the posterior border of this muscle, the nerve reaches the base of the tongue, and sends twigs to the anterior surface of the epiglottis. It terminates in fibres which are distributed to the basal third of that organ, as far as the circumvallate papillæ.

While within the posterior lacerated foramen the trunk is complicated by the presence of two ganglia. The *first ganglion* (ganglion of Ehrenritter; ganglion of Joh. Müller, jugular ganglion) is inconstant, and is not described by all authors. When present, it lies to the outer side of the trunk, and involves but a portion of its fibres. According to Hyrtl, it sends a filament to the superior cervical ganglion.

The *second ganglion* (petrosal ganglion; ganglion of Andersch) is more important than the first, and is constantly present. It lies in a depression of the petrous portion of the temporal bone, just as the nerve is about to escape from the lacerated foramen to descend the neck. The ganglion is small, measuring three lines in length, is of an oval form, and involves the whole thickness of the nerve. It unites with the first cervical sympathetic ganglion, and with the auricular branch of the pneumogastric nerve.

The Branches from the Glosso-Pharyngeal Nerve are as follows:—

Tympanic.
Pharyngeal.
Muscular.
Tonsillar.
Anastomotic.
Lingual.

The Tympanic Branch[1] (nerve of Jacobson) is a slender cord passing from the ganglion upward and a little outward, to enter a minute canal seen upon the ridge between the carotid foramen and the jugular fossa, to the outer side of the aqueduct of the cochlea. The nerve ascends along the internal wall of the cavity of the tympanum, and sends a branch to the promontory, near which it lies; another to the region of the oval and round windows; and a third to the membrane lining the cartilaginous portion of the Eustachian tube, beneath the mucous membrane of which it forms a minute plexus. It sends two anastomotic filaments to the carotid plexus of the sympathetic, and one to the great superficial petrosal nerve, as it lies in the hiatus Fallopii. The nerve pierces the anterior wall of the tympanic cavity under the name of the *small superficial petrosal nerve*, and terminates in the otic ganglion. A filament is described as joining the geniculate ganglion of the facial, which some authors regard as a terminal branch.

These communicating branches form what is known as the *tympanic plexus.*

Pharyngeal Branches (pharyngo-basilares), from two to four in number, join the pharyngeal plexus, and supply through it the Superior and Middle Constrictor muscles.

A Muscular Branch is distributed to the Stylo-Pharyngeus muscle and the mucous membrane of the pharynx. It may pierce the muscle near the tongue, to supply the lateral borders of the base of that organ. According to Rüdinger, a nerve may be secured from the branch of communication with the facial.

Tonsillar Branches are distributed to the mucous membrane of the tonsil and its immediate neighborhood, and a branch is given off to the Palato-Glossus muscle and to the soft palate.

An Anastomotic Branch (carotid branch) joins the carotid plexus of the sympathetic nerve; another passes from the petrosal ganglion to the jugular ganglion of the pneumogastric nerve, or to the auricular branch of this nerve; and a third joins the facial nerve.

The Lingual Branches are terminal. They are confined to the mucous membrane of the base of the tongue, as already mentioned, and to the papillæ at the side of the tongue.

Several minute filaments of the encranial portion supply the adjacent pia mater and arachnoid membrane.—Hirschfeldt mentions a branch of the nerve which may be traced forward in the tongue beyond the basal third. The taste buds (q. v.) are supposed by some writers to be supplied exclusively by the glosso-pharyngeal nerve. Luschka assigns motor twigs from the nerve to the posterior belly of the Digastric muscle to the Stylo-Hyoid muscle, and branches to the intercarotic body. The same writer describes a branch to the mastoid cells.—Ganglionic cells have been demonstrated by W. Krause in the branch beneath the mucous membrane of the Eustachian tube and tympanum.—Cruveilhier mentions an anastomotic branch with the facial branch of the second ganglion, which runs downward and outward behind the styloid process, and joins the facial nerve immediately after its exit from the stylo-mastoid foramen.

The bloodvessels of the apparent origin of the glosso-pharyngeal nerve are derived from the vertebral artery (Duret).

Variations.—The fibres of apparent origin may lie between those of the facial and auditory nerves. In the absence of filaments of the facial nerve to the muscles about the

[1] See, in connection with this, Virchow's Archiv, 1875, iv.

pharyngeal orifice of the Eustachian tube, twigs of the glosso-pharyngeal nerve may take their place. The terminal branches of the nerve may interchange with the mylo-hyoid nerve.—The first ganglion may be absent. The branch of union with the auricular branch of the pneumogastric may yield fibres to the facial nerve.

Remarks.—The glosso-pharyngeal nerve is less frequently the subject of clinical study than any of the series of cranial nerves.

The fact that the base of the tongue receives general sensibility from filaments of this nerve is exemplified in the instance of excision of a portion of the trunk of the gustatory nerve, to relieve the pain of cancer in this portion of the tongue. When the ravages of the disease extend backward far enough to involve the base of the tongue, the pains return (see Fifth Nerve).

While dysphagia or aphagia from disease of the central nervous system may, on general grounds, be associated with degeneration of the nuclei of origin of the glosso-pharyngeal nerve, it would be difficult, if not impossible, to disassociate such degeneration from that of the nucleus of the pneumogastric nerve. At least, as far as the writer is informed, no autopsy has been recorded in which is described degeneration involving the nucleus or the trunk of the glosso-pharyngeal nerve.

An analogy may be instituted with advantage between parts of the fifth, the seventh, and the ninth nerve. The fifth and seventh nerves supply the apparatus of mastication, as the ninth supplies the apparatus of deglutition. In both of these acts, sensory and motor functions are united. In mastication (as well as in the prehension of food), the elevation and depression of the jaws, and the adaptation of the cheek tissues, are secured by the motor branches of the fifth and the seventh, and the sensory branches are also derived from the fifth nerve. In deglutition, both the motor and sensory functions are performed by one nerve, the glosso-pharyngeal. The union of the regions of mastication and deglutition is seen in the ranges of variation of the facial nerve by which it is compensatory with the glosso-pharyngeal in the region of the soft palate, and in the anastomoses of these nerves through the tympanic branch of the glosso-pharyngeal.

The tactile sensibility of the mucous membrane of the naso-pharynx is much less than that of the oro-pharynx. A pin or other foreign body may be lodged in the naso-pharynx for a long time, and the distress arising from its presence be comparatively insignificant.[1] Sensibility in the oro-pharynx, and particularly at the base of the tongue, the epiglottis, and the pyriform sinuses, is of higher grade, and general distress follows upon slight intrusions.

The distribution of a filament of the nerve to the anterior two-thirds of the tongue (see p. 534) is interesting in connection with the localization of the sense of taste. Under the head of the fifth nerve, a case of paralysis is narrated, in which taste was retained at the base of the tongue, but was impaired at the anterior two-thirds of the organ. The fact that taste was not destroyed with the loss of general sensibility may be attributed to the presence of the filament just alluded to. Some writers, indeed, hold that the glosso-pharyngeal nerve is the only nerve controlling the sense of taste.

THE PNEUMOGASTRIC, OR THE TENTH NERVE.

The Pneumogastric or Tenth Nerve is the great visceral nerve of the body. It furnishes sensory and motor fibres to the larynx, and in part to the soft palate and the pharynx; inhibitory nerves to the heart and alimentary canal; sensory nerves to the middle ear; and assists in the composition of the plexuses of the pharynx, of the œsophagus, and of the thorax and abdomen. It forms communications with the spinal accessory, glosso-pharyngeal, facial, hypoglossal, and spinal nerves.

The nerve has a *true* origin from the trineural fasciculus, and a *nucleus* lodged in the gray matter of the floor of the fourth ventricle. The fasciculus tends to divide the nucleus into two portions, a median and a lateral, the former being the larger of the two. The nerve is believed by some observers to secure simply an accession from the fasciculus. The intrinsic fibres pass obliquely downward and outward through the gelatinous substance. The nerve has its *apparent* origin by fifteen to twenty filaments from a groove at the side of the medulla oblongata between the olivary and the restiform bodies. In front of these filaments lie those of the glosso-pharyngeal nerve, and behind them those of the spinal accessory nerve. The filaments gradually unite, and pass transversely outward, constituting the *encranial portion* of the trunk. While passing through the foramen the nerve is lodged within a process of dura mater and arachnoid in common with and in front of the spinal accessory nerve. Above it lies the glosso-pharyngeal nerve, from which it is separated by a fibrous or bony partition. Within the foramen

[1] G. W. Ward, Arch. of Clin. Surg., i., 1876–77, 336.

the nerve is enlarged by the presence of the jugular ganglion. The *jugular ganglion* (upper ganglion, ganglion of the root, first ganglion) is an oval or nearly spherical body, of about two lines in diameter, which embraces all the fibres of the nerve, as they escape from the cranium at the posterior lacerated foramen.

The *excranial portion* of the nerve assumes a vertical position, and descends the neck in front of the internal jugular vein. A short distance without the foramen lies the cervical ganglion. The *cervical ganglion* (inferior ganglion, ganglion of the trunk, second ganglion) is a flattened, elongated body, from six to ten lines long, and about two lines wide. It is of somewhat open plexiform character (hence the name sometimes given it—*plexus ganyliformis*), and results from the early union of the majority of the pneumogastric fibres with a portion of those of the spinal accessory nerve. It thus does not involve all the fibres of the pneumogastric nerve, a small fasciculus being retained independent of it for anastomosis with the internal division of the last-named nerve. The ganglion is also in association with the glosso-pharyngeal and hypoglossal nerves, as will be seen under the section treating of the anastomotic branches of the pneumogastric.

Below the cervical ganglion the main trunk of the nerve descends the neck upon its deep muscles to the side of the pharynx. From its position in front of the internal jugular vein it gradually passes to the inner side of and somewhat behind the vein, and close to the outer side of the internal carotid artery above, and the primitive carotid, below. From the region of the hyoid bone it is inclosed in the same sheath with these vessels, and is separated from the prevertebral muscles by a quantity of loose connective tissue containing the sympathetic nerve of the neck.

Both nerves deviate a little to the outer side as they pass through the base of the neck, and afterward approximate the median line at the roots of the lungs, where they unite to some extent along the œsophagus in forming the *œsophageal plexus*. In some important relations the two nerves differ.

The *right pneumogastric nerve* passes between the subclavian vein and artery, and lower down between the innominate vein and superior vena cava, and behind the phrenic nerve, crossing the arch of the aorta to descend in the groove between the trachea and œsophagus, and to reach the root of the right bronchus. It is here somewhat flattened and held to the posterior surface of the bronchus, by some short fibres of connective tissue, as it joins the nerve of the opposite side in the posterior pulmonary plexus. Below this point the nerve gradually approaches the œsophagus, and extends along its posterior surface to enter into the œsophageal plexus.

The nerve passes through the Diaphragm with the œsophagus, and its fibres are spread out upon the posterior surface of the stomach, sending branches to the liver and to the solar plexus.

Henle alone states that the fibres to the solar plexus have not been satisfactorily demonstrated by dissection, although experimentation suggests their existence.

The *left pneumogastric* nerve enters the thorax concealed at first between the left innominate vein and the left subclavian artery, parallel to both the latter structures and to the left carotid artery. It then passes in front of or to the left of the aortic arch, being in consequence a little more advanced than the right, and is internal to or behind the phrenic nerve. It subsequently lies upon the anterior surface of the œsophagus, and maintains the same relation upon the stomach. Within the abdomen the pneumogastric terminates by branches which are lost upon the liver, the pancreas, the spleen, and the small intestine.

The Branches of the Pneumogastric Nerve:—

- Encranial,
  - Auricular.
  - Meningeal.
- Excranial,
  - Cervical,
    - with the spinal accessory nerve.
    - with the glosso pharyngeal nerve.
    - with the hypoglossal nerve.
    - with the sympathetic system.
  - Anastomotic,
  - Pharyngeal and Laryngeal,
    - Pharyngeal.
    - Superior laryngeal.
    - Inferior laryngeal.
  - Thoracic,
    - Thoracico-cardiac.
    - Pulmonary.
    - Œsophageal.
  - Abdominal,
    - Hepatic, gastric, and intestinal.

The Auricular branch (auricularis vagi) comes off at the jugular fossa. This nerve is subject to much variation. It arises from the superior ganglion, passes across the jugular fossa behind the bulb of the internal jugular vein, and is joined by a filament from the glosso-pharyngeal nerve. It then passes through a small canal in the temporal bone to the Fallopian canal, near its outlet, where it joins the facial nerve, and subsequently passes through a minute canal between the tympanic and mastoid portions of

the temporal bone, and then divides into two branches, of which one anastomoses with the posterior auricular branch of the facial nerve; the other terminates in the skin and cartilage of the external ear.

The Meningeal Branch. From the anterior border of the jugular ganglion a small meningeal branch is seen, which turns backward and supplies the dura mater in the neighborhood of the posterior lacerated foramen.

The Anastomotic Branches. — The anastomotic branches of the pneumogastric nerve represent motor filaments which are received into the pneumogastric nerve at its inferior ganglion. The majority of these appear to be retained within the trunk of the nerve, while others are conveyed, some to the glosso-pharyngeal nerve, others to the pharyngeal plexus.

The following list of anastomotic branches is selected in the main from Sappey:—

(*a*) *With the spinal accessory nerve.*—This is placed behind the pneumogastric at its passage through the skull. It yields, as a rule, several filaments to the jugular ganglion, and at its division gives the internal branch to the ganglion. This joint branch (viz., from the internal branch, the spinal accessory, and a branch of the pneumogastric) sends a superior branch to the pharynx; and an inferior branch passes along the outer side of the trunk of the pneumogastric nerve.

(*b*) *With the glosso-pharyngeal nerve.*—This is an inconstant branch, which is formed through an anastomosis with the roots of this and the pneumogastric nerve, or between twigs of the pharyngeal plexus. It may unite the jugular ganglion of the pneumogastric with the petrosal ganglion of the glosso-pharyngeal. The motor filaments described as joining the glosso-pharyngeal from the inferior plexus are more properly fibres derived primarily from the internal division of the spinal accessory.

(*c*) *With the hypoglossal nerve.*—This is a very variable branch. It is ordinarily composed of two or three filaments which arise from the hypoglossal nerve, immediately after it crosses the cervical ganglion. The trunk of the hypoglossal nerve crosses the cervical ganglion at an acute angle, and is held to it by firm connective tissue.

(*d*) *With the ganglia of the sympathetic system.*—This is an intimate relation, but varies in the number of the filaments involved, their volume and direction. The upper filaments are directly transverse; the lower, however, are more oblique.

The Pharyngeal Branches are from one to two in number. They are derived from the upper and external part of the inner border of the cervical ganglion. They pass downward and inward behind the internal carotid artery (rarely in front of it), along the upper border of the Middle Constrictor muscle, and join branches from the glosso-pharyngeal, superior laryngeal, and sympathetic nerves, to form the *pharyngeal plexus.* This important anastomosis is situated behind the Middle Constrictor muscle, about the ascending pharyngeal artery. It sends branches to the muscles and mucous membrane of the pharynx.

The Superior Laryngeal Nerve arises from the middle of the inner side of the cervical ganglion, below the pharyngeal branch, as a rounded cord, which passes in a curved direction downward and inward, behind the internal and external carotid arteries. It is an important nerve, being the motor nerve to the Crico-Thyroid muscle, and distributing branches to the Inferior Constrictor and the Arytenoid muscles, as well as to the mucous membrane at the base of the tongue, the posterior surface of the epiglottis, the larynx, and the mucous membrane of the pharynx as it joins the posterior wall of the larynx. It passes along the upper margin of the Inferior Constrictor muscle, and divides, as it lies upon the lateral wall of the pharynx beneath the artery, into two branches, the external and internal laryngeal branches. The *external laryngeal branch* is remarkable for its length. It lies between the thyroid cartilage and the Inferior Constrictor muscle, and sends branches to this muscle, to the Crico-Thyroid muscle, and to the thyroid body. It anastomoses with the terminal branches of the inferior laryngeal nerve, and joins the superior cardiac nerve or cardiac plexus, and may send a branch to join the superior cervical ganglion of the sympathetic. The internal laryngeal branch supplies the interior of the larnyx with general sensibility. It sends a branch of communication to the inferior laryngeal nerve.

According to Henle, this nerve receives branches from the pharyngeal plexus as well as from the superior cervical ganglion. It yields some filaments which pass between the thyroid cartilage and the cricoid cartilage, and traverse the Crico-Arytænoideus Lateralis muscle, to ramify upon the mucous membrane of the ventricle of the larynx. According to Hyrtl, a constant branch of union joins the descendens noni, and another joins the cardiac plexus.

The *internal* laryngeal nerve passes between the hyoid bone and the thyroid cartilage to the thyro-hyoid membrane, along which it passes to the median line; there it pierces the membrane to reach the interior of the larynx, where it becomes submucous,

and abruptly divides into a network of branches, which are distributed as follows:—

The anterior branch, which passes upward in the arytæno-epiglottidean fold to the posterior surface of the epiglottis. According to Cruveilhier, some of its terminal filaments pierce the cartilage to appear upon its anterior surface. Several branches pass downward to supply the arytæno-epiglottidean fold and the mucous membrane around the glottis.—A branch to the base of the tongue. This ascends as far as the circumvallate papillæ. — Posterior branches to the Arytænoid muscles and mucous membrane of the posterior aspect of the interior of the larynx. According to Cruveilhier, they perforate the muscle from behind forward, and its fibres are distributed partly to it, and partly to the lining membrane of the larynx.

The Inferior Laryngeal Nerve (recurrent laryngeal) arises from the main trunk, at the beginning of the thoracic portion, and ascends along the trachea and œsophagus, to the level of the crico-thyroid articulation, where it divides into its terminal branches, which supply motor filaments to the muscles of the larynx, excepting the Crico-Thyroid. Its course differs on the two sides of the body.

The *left* nerve winds round the arch of the aorta, directly below the remains of the ductus arteriosus, to gain the space between the common carotid artery and the trachea. It is longer than the right, and lies in front of the œsophagus.—The *right* nerve turns beneath the common carotid and inferior thyroid arteries, round the right subclavian artery. At first a little oblique, it becomes vertical, and lies as it ascends the neck upon the side of the œsophagus. The right nerve may send a branch to the pericardium, and a branch to the inferior cervical ganglion.

The inferior laryngeal nerve supplies tracheal and œsophageal filaments. The latter, for the most part, pass upward in a direction nearly parallel to that of the principal trunk.

The Pulmonary Branches are composed of two sets of branches, an anterior and a posterior. Of these, the posterior is the larger. The *anterior pulmonary plexus* rests upon the pulmonary artery, and is composed of two or three pneumogastric filaments conjoined with a few accessions from the sympathetic system. The fibres of the *posterior pulmonary plexus* join those of the sympathetic from the second, third, and fourth thoracic ganglia.

The Terminal Branches. Those of the left pneumogastric nerve lie for the most part along the lesser curvature of the stomach, although several branches are dispersed over the anterior surface at the cardiac end. From among these branches the hepatic branch is derived, which, entering the gastro-hepatic omentum, is conducted to the transverse fissure of the liver, whence it enters the hepatic substance.—The branches of the right pneumogastric nerve pass more to the posterior part of the stomach, where they send important branches to the solar plexus, thence to supply the pancreas, spleen, and small intestine.[1]

The apparent origin and the encranial portion of the pneumogastric nerve derive their arterial blood supply from the vertebral artery. (Duret.)

Variations.—The nerve, while in the sheath of the great vessels, may lie in front of both the artery and the vein.

The inferior laryngeal nerve, according to Henle, divides into two branches, one of which is distributed to the Crico-Arytenoideus Posticus, and extending between it and the cricoid cartilage to the Arytenoideus; while the other is received upon the muscles on the lateral wall of the larynx.

When the right subclavian artery arises from the left aortic root, the right recurrent laryngeal nerve is absent. In its place a number of branches are distributed to the larynx, to the inferior part of the pharynx, to the trachea, and to the œsophagus. The laryngeal branch may resemble in volume the normal recurrent laryngeal.[2] The nerve may infrequently arise from the main trunk at the level of the lower border of the cricoid cartilage.

Francois-Frank found the anastomosis between the superior and inferior laryngeal nerves to be composed entirely of sensitive fibres of the superior laryngeal nerve, and to be distributed to the lining membrane of the trachea and the larger bronchial tubes.

The superior laryngeal nerve may run in front of the internal carotid artery. It frequently unites, by a small filament, with the superior cervical ganglion, or with the superior cardiac nerve. It may give a branch to each of the following muscles: the Sterno-Thyroid, the Thyro-Hyoid, and the Lateral Crico-Arytenoid.

A branch from the interior of the larynx may arise distinct from a branch to the exterior of the larynx.

J. Kollman traces the terminal filaments of the pneumogastric nerve to the alimentary canal and to its appendages in the abdominal cavity.

Remarks.—The anatomy of the pneumogastric nerve is clinically applied to the influence of the nerve (*a*) on the ear and through the ear upon the respiratory tract; (*b*) to its action on the heart and lungs; (*c*) to the action of the laryngeal muscles; and (*d*) to its connection with the innervation of the abdominal organs.

[1] J. Kollman, Zeit. f. Wissen. Zool., x. 1860, 413, fig.

[2] Damarquay, Gaz. Méd. de Paris, Sept. 9, 1848.

(*a*) Cough is frequently excited by the irritation arising from a foreign body in the external meatus, and pharyngeal irritation is maintained through reflex action originating in the external meatus and in the middle ear. These conditions are explained by the distribution of the auricular branch, and by the communications of the superior ganglion.

(*b*) Clinicians have recognized the importance of studying the conditions of the thoracic lymphatic glands in connection with the position of the pneumogastric nerves. In the autopsy of a man who had suffered from pulmonary disease accompanied with dyspnœa, the right pneumogastric nerve in its thoracic portion was found by Richet[1] thickened, inflamed, and compressed by a mass of enlarged lymphatic glands.

Great rapidity of the heart's action is often associated with chronic phthisis of the apex of the lung. A. D. Anderson,[2] in excising a sarcoma of the neck, removed a portion of the pneumogastric nerve with a fatal result.

(*c*) G. Johnson[3] points out the fact that bilateral spasm and bilateral palsy of the intrinsic muscles of the larynx may result from the pressure of an aneurism or other tumor on the pneumogastric nerve of one side only. In such a case the vocal cords retained their natural color, nearly touching each other in the median line, and almost motionless. A slight approximation of the cord occurred during vocalization. During inspiration, the glottis did not expand as in the normal state, but, on the contrary, the cords appeared to be pressed nearer together by the inspiratory current, while in expiration the cords were slightly pushed apart. At the post-mortem examination an aneurism about the size of an orange was found projecting backward from the arch of the aorta, and involving the trunk of the left pneumogastric nerve. The left recurrent nerve passed around and behind the tumor, where it was also compressed, atrophied, and nearly lost in the wall of the aneurismal sac. Both recurrent nerves in their regions of ultimate distribution were atrophied, especially those of the left side. In a similar case, reported by Baümler,[4] the atrophy was symmetrical. Such results of pressure do not follow when either recurrent nerve is alone compressed, and are not, therefore, due to the fibres of the recurrent nerves crossing the median line, but to certain obscure causes underlying disturbed states of the brain centres.

The recurrent laryngeal nerves are not infrequently pressed upon by aneurismal swellings in the thorax, with resultant paralysis of the muscles of phonation —particularly the muscles of abduction. G. Johnson[1] narrates a case in which pressure upon the left recurrent nerve caused paralysis of both vocal cords.

(*d*) In an important series of experiments on animals, H. C. Wood[2] found the integrity of the pneumogastric nerve to be essential to the functional integrity of the small intestine. After section of the nerve-trunks within the abdomen, the action of purgative drugs was notably retarded, and in some instances arrested.

THE SPINAL ACCESSORY, OR THE ELEVENTH NERVE.

The Spinal Accessory or Eleventh Nerve is a motor nerve which supplies the Sterno-Cleido-Mastoideus muscle, in part the Trapezius, and, through the medium of branches to the pneumogastric nerve, controls the acts of phonation.

The spinal accessory, so called from its position in relation to the pneumogastric nerve and the spinal cord, holds a peculiar place among the cranial nerves, inasmuch as it contains an important group of fasciculi from the cervical portion of the cord, in addition to its fibres of origin from the floor of the fourth ventricle. The *true origins* of the spinal accessory nerve are thus both spinal and medullary. The spinal origin lies in the entire length of the intermediary lateral tract, and in the reticular formation above. The medullary origin lies in the dorsal portion of the central gray matter, just prior to the formation of the fourth ventricle, as well as in the lower part of the trineural fasciculus, and receives an accession from the hypoglossal nucleus and the raphe.

The *cervical intrinsic fibres* ascend from the cervical portion of the cord, through the lateral columns, and turn outward to become apparent at the side of the cord between the anterior and the posterior roots, but nearer the latter than the former. The *medullary intrinsic fibres* pass obliquely downward and outward, and become apparent at the lower part of the medulla, in the groove between the olivary and restiform bodies.

The *apparent origin* of the nerve can be traced usually the entire length of the cervical portion of the cord, but may be found answering to the levels

[1] Anatomie Chirurg., 568.
[2] Glasgow Medical Journal, iii., 1855, 276 (56?).
[3] Med. Chir. Trans., 1875, 29.
[4] Trans. Path. Soc. London, vol. xxiii. 66.

[1] Trans. Path. Soc. Lond., 1873, 42.
[2] Am. Jour. Med. Sci., 1870.

of the apparent origins of the third or fourth cervical nerves only. The filaments are from ten to twelve in number, and lie between the denticulate ligament and the lateral groove. Of these, six to seven are cervical; the remainder are medullary. From this extensive origin, the nerves converge to form a trunk at the posterior lacerated foramen, through which they pass in the same sheath with the fibres of the pneumogastric nerve.

Immediately after the nerve escapes, it divides into two branches, an internal and an external. The *internal branch* contains, it is thought, the medullary fibres; is intimately associated with the cervical ganglion of the pneumogastric nerve, and terminates in branches which join with this nerve. It sends a minute branch to the pharynx, another joins the hypoglossal nerve, and another the recurrent laryngeal nerve.

The *external branch* contains the cervical fibres. It passes obliquely downward and outward between the common carotid artery and the internal jugular vein; and descends the neck between the vein and the occipital artery. It passes over the transverse process of the first cervical vertebra to gain the median border of the Sterno-Cleido-Mastoideus muscle at its upper third. The nerve pierces this muscle, and reappears much diminished in size in the supraclavicular fossa or upon a line uniting the mastoid process with the acromion, when it passes behind the Trapezius, and is distributed to the clavicular portion of this muscle.

The branches of the external branch other than those already given are a constant anastomotic branch with the first cervical nerve; one or two filaments joining the first ganglion of the pneumogastric nerve; branches joining the third, fourth, and fifth cervical nerves, and with them assisting to form the cervical plexus.

The apparent origin of the spinal accessory nerve derives its arterial supply from the anterior spinal artery (Duret).

Variations.—The spinal accessory nerve frequently secures a twig from the second cervical nerve. Infrequently the nerve receives all the fibres of the posterior root of the first cervical nerve. Fleischman detected a ganglion on the root of the nerve. The main trunk may lie behind the internal jugular vein, and may not pierce the Sterno-Cleido-Mastoideus muscles, but become superficial along its lateral border. At its external division the nerve may unite with the descendens noni.

Remarks.—The union between the external branch and the first cervical nerve is so intimate that the two are often held within the same sheath. The nerve, from its position in the neck between the transverse process of the atlas and the internal jugular vein, can be exposed by an incision made along the anterior margin of the Sterno-Cleido-Mastoideus muscle just opposite the transverse process of the atlas.[1] The nerve was divided with success in contracture of the Trapezius muscle in torticollis by C. D. Morgan,[2] who, in order to reach the trunk, made an incision two inches long at the *posterior* border of the Sterno-Cleido-Mastoideus muscle. The branch to the Trapezius was found and divided as it emerged from beneath the Sterno-Cleido-Mastoideus.

Physiological experiments prove that the anterior division of the spinal accessory nerve, which is received within the trunk of the pneumogastric nerve, controls laryngeal phonation. Bernard suggests that the branches to the Sterno-Cleido-Mastoid and the Trapezius muscles correlate in function with the laryngeal branches by sustaining the neck and thorax in such positions as will enable a prolonged expiration to be economized to the best advantage during phonation. This hypothesis is especially illustrated by the prolonged cries of the lower animals.

THE HYPOGLOSSAL, OR THE TWELFTH NERVE.

The Hypoglossal, or Twelfth Nerve, is the motor nerve of the tongue, and aids in depressing the hyoid bone.

The true origin of the nerve lies in a *nucleus* which is continuous with the bases of the anterior cornua of the gray matter of the medulla. It is well seen in the lower part of the tubular gray matter just before the opening out of this mass to form the floor of the fourth ventricle. It lies beneath the floor of the fourth ventricle at its lower end behind the funiculus teres, at a spot which is sometimes known as the hypoglossal triangle. The conspicuous cells are multipolar. Some fibres are derived from the raphe.

The *intrinsic fibres* pass downward and outward in a direction subject to slight variation with respect to the olivary bodies, but frequently passing through them to become apparent at a groove between the olivary body and the anterior pyramid. The nerve comprises from twelve to fourteen filaments, which are arranged in two bundles, each being inclosed within a separate tube of dura mater. The *encranial portion* lies behind and above the vertebral artery, and is intimately surrounded by a circle of small veins tributary to the cranial circular sinus of the foramen

[1] Burns, Top. Anat. of Neck, 260.

[2] Br. and For. Med.-Chir. Rev., July, 1866.

magnum. It escapes from the brain-case through the anterior condyloid foramen. In its *excranial portion* the nerve descends the vertebral column in a nearly vertical direction, at first behind and to the median side of the pneumogastric nerve, and then between the internal carotid artery and the internal jugular vein. It soon passes in front of the internal and external carotid arteries as it curves downward and forward to reach the infra-maxillary region, where it lies beneath the Mylo-Hyoid muscle and upon the Hyo-Glossus muscle, at the median border of which it enters the side of the tongue to supply the intrinsic lingual muscles. The trunk at first lies in front of the external carotid artery, beneath the posterior belly of the Digastric, or extends along the median border of this muscle, and that of the Stylo Hyoid muscle. While upon the Hyo-Glossus muscle it lies above the lingual artery, which is beneath the muscle just above the hyoid bone. In the substance of this organ the artery lies to the outer side of the Genio-Glossus muscle, while the nerve runs forward through the fibres of the muscle.

The Relation of the Hypoglossal Nerve and the Cervical Branches.—In intimate mechanical association with the lateral border of the trunk of the hypoglossal nerve, from the point where it ceases to be vertical to the point where it enters the tongue, is a nerve formed by the union of the first, second, and third cervical nerves, which will in this work receive the name of the *cervico-hypoglossal nerve.* It sends off several branches which descend the neck, and which, for convenience in topographical description, are included among branches of the hypoglossal nerve. They are as follows:—

Descending branch.
Thyro-hyoid branch.
Genio-hyoid branch.

The *Descending Branch* (descendens noni) leaves the hypoglossal nerve where it turns round the occipital artery, and is joined by a branch from the first and second cervical nerves, called the *communicans noni*, which passes down the neck to a position just above the tendon of the Omo-Hyoid muscle, where it communicates with other branches of the second cervical nerve. The descendens noni is strengthened in addition by a branch from the third cervical nerve, which ascends parallel to the course of the descending fibres. In this way a loop is formed at the side of the neck, one limb of which goes to the cervical nerves, and one to the hypoglossal. The union of the limbs often forms a plexus, which gives off branches from its convex side to the Sterno-Hyoid and Sterno-Thyroid muscles, and to the superior belly of the Omo-Hyoid muscle.

The *Thyro-Hyoid Branch* arises from the cervico-hypoglossal, in advance of the descending branch, and supplies the Thyro-Hyoid muscle.

The *Genio-Hyoid Branch* arises from the same nerve as the preceding, but nearer the median line of the neck. It supplies the Genio-Hyoid muscle.[1]

The *True Branches of the Hypoglossal Nerve.* The branches of the hypoglossal nerve are as follows:—

The Branch to the superior cervical ganglion.
The Branches to the pneumogastric plexus.
Recurrent branch.
Vascular branch.
Muscular branches.

The *Branch to the superior cervical ganglion.* The nerve, soon after its escape, sends conspicuous branches to the upper end of the superior cervical ganglion.

The *Branches to the pneumogastric plexus.* These are united to the posterior surface of the plexus by firm connective tissue.

The *Recurrent branch* arises from the trunk within the anterior condyloid foramen, and passes to the dura mater of the canal and the region about its encranial orifice, and the walls of the circular sinus of the foramen magnum. According to Luschka, it also supplies the occipital diploë.

The *Vascular Branch* is composed of one or two filaments which supply the walls of the internal jugular vein.

The *Muscular Branches* supply the Stylo-Glossus and the Hyo-Glossus muscles.

The encranial portion of the nerve receives a twig from the anterior spinal artery (Duret).

The nerve, as it passes over the Hyo-Glossus muscle, may send a branch to this and the Stylo-Hyoid muscle, as well as to the submaxillary ganglion and to the gustatory branch of the fifth nerve. Filaments have been detected by Luschka joining the pneumogastric and glosso-pharyngeal nerves.

Variations.—The hypoglossal nerve, while within the anterior condyloid foramen, may receive a twig from the first cervical nerve. Infrequently, a ganglion which is constantly present in some animals has been found on the trunk of the nerve near its apparent origin. The trunk of the nerve may be embraced in an island formation of the vertebral artery. The right and left nerves may unite in the

[1] Writers prior to Bach (Annotationes Anat. de nervis hypoglosso et laryngeo, Zurie, 1835) derived the branches above described entirely from the hypoglossal. Luschka, E. Bischoff, and M. Holl (Zeit. f. Anat. u. Entwickelungesch., 1879, ii. 82, figs.) have completed our knowledge on the subject. The identification of the branch to the Genio-Hyoid muscle is due to Holl.

fibres of the Genio-Hyoid muscle, or between this muscle and the Genio-Glossus. The descending branch of the cervico-hypoglossal nerve may yield a cardiac branch; it frequently unites with the phrenic nerve. The trunk of the nerve may lie to the outer side of the internal carotid artery. The descendens noni is occasionally placed within the carotid sheath, instead of in front of it.

According to Luschka, a recurrent lingual branch arises from the hypoglossal by numerous filaments. Some of these pass beneath the trunk of the nerve, to join filaments from the first cervical ganglion, whence they pass to the median side of the internal jugular vein. The descending cervical branch may arise entirely from the first and second cervical nerves, and have no connection with the hypoglossal. It may secure a branch from the pneumogastric nerve.[1] The right and left nerves may be united by a branch in front of the hyoid bone.[2]

The twelfth may be fused with the eleventh nerve as far as the posterior belly of the Digastric muscle. The descendens noni may fuse with the eleventh nerve for a variable distance.

Remarks.—The clinical application of a knowledge of the twelfth nerve can be discussed under the following heads: (*a*) the nucleus of origin and the intrinsic fibres; (*b*) the nerve in transit through the skull, and as it lies at the nape of the neck; (*c*) as it descends the neck; and (*d*) as it is distributed within the tongue.

(*a*) The nucleus and intrinsic fibres are of necessity involved in all lesions of the lower portion of the medulla near the central canal. Degeneration of the nucleus will involve the lingual muscular structure only, since the Genio-Hyoid muscle and the depressors of the hyoid bone are supplied by cervical nerves.

(*b*) In consequence of the relation of the nerve-trunk to the vertebral artery Luschka believes that it is possible for turgescence of the vessel to induce pressure upon the nerve. This, however, excepting in aneurismal dilatation of the vessel, need scarcely be considered. Pressure from the veins surrounding the encranial portion of the nerve may also occur. After the death of a person who had for years complete paralysis of one-half of the tongue, a cystic tumor was observed by Cruveilhier occupying the anterior condyloid foramen of the corresponding side.—Necrosis of the occipital bone at the place of exit of the nerve may cause paralysis of the corresponding half of the tongue (see p. 122).

(*c*) The hypoglossal nerve is a guide to the external carotid artery. M. Guyon[1] found this nerve crossing the vessel at about the point where the lingual artery arises from the main trunk.—The hypoglossal nerve on the neck has been divided in operations, more particularly in opening abscesses. The nerve has been frequently severed in gunshot and other wounds.—This portion of the nerve is so closely related to the branches of the cervical nerves that in clinical studies the two sets of fibres should be carefully separated. It is evident that division of the median fibres of the trunk would affect the tongue only, while division of the lateral fibres would paralyze the depressors of the hyoid bone, and the Genio-Hyoid muscle.

When the nerve is paralyzed, the tongue, if protruded, is deflected to the diseased side. The mechanism of this is as follows. The Stylo Glossus and Hyo-Glossus muscles being paralyzed, the hyoid bone tends to be depressed on the side corresponding to the paralysis; so that the tongue, when protruded, sags on the affected side. This appearance is exaggerated by the fact that the paralyzed side of the organ is longer than the normal one. The Genio-Glossus muscle assists in maintaining the deflection.

(*d*) According to L. Hermann,[2] the hypoglossal nerve receives sensory fibres through its so-called descending branch from the first cervical nerve in consequence of which the tongue retains a certain amount of sensibility even after division of the fifth nerve.

[1] S. Parkman, Am. Journ. Med. Sci., xi., 1846, 392.
[2] W. Brinton, Trans. Path. Soc. London, ii., 1850, 30.

[1] Mémoires de la Soc. de Chir. de Paris, 197.
[2] Physiol. (Eng. Trans.), 372.

THE SPINAL NERVES.

THE Spinal Nerves are arranged in thirty-one pairs, as follows: The cervical nerves, eight in number; the dorsal nerves, twelve in number; the lumbar and sacral nerves, each five in number; and one pair of coccygeal nerves.

Each spinal nerve arises[1] by two roots, named from their relations one to the other, the anterior and the posterior root. The *anterior root* arises from the spinal cord between the anterior and lateral columns, the *posterior* root from the postero-lateral fissure.

The size of the nerve-roots is correlated with the extent and complexity of the regions to which the nerve-trunks go. Thus, the roots of the nerves passing to the limbs are larger than those of the nerves passing to the neck and to the sides of the chest. The anterior nerve roots are, with the exception of the first and the second cervical nerves, smaller than the posterior. The nerve-roots are further distinguished by the constant presence of a small ganglion upon each posterior root a short distance from the spinal cord. The two roots pass through separate openings of the dura mater, and form one bipartite trunk, which soon divides into an anterior and a posterior portion.

The spinal nerves escape from the vertebral canal by the intervertebral foramina.

Each nerve is divided into an envertebral and an exvertebral portion.

The *envertebral portions* are equidistant in the cervical region, but approximate, and become more oblique below. The distance between the origins of the nerves increases from above downward. At the level of the second lumbar vertebra a bundle of very oblique and vertical nerves is formed, termed the cauda equina. The *cauda equina* is composed of the lumbar, sacral, and coccygeal nerves, and lies in the vertebral canal from near the termination of the spinal cord, to the points of exit of its several strands through the intervertebral and sacral foramina.

The envertebral portions of the spinal nerves are inclosed in tubular sheaths of dura mater, and are surrounded by the veins of the vertebral plexus and by lymph. The ganglia are situated upon the envertebral portion of all the nerves. In the case of the cervical, dorsal, and thoracic nerves, they lie within the intervertebral foramina, but are placed upon the sacral and coccygeal nerves while these are yet in the vertebral canal. The sacral and coccygeal nerves differ still further from the cervical, dorsal, and lumbar by dividing before their escape from the canal, while the others divide immediately after their escape. Considered as a group, the envertebral portions of the nerves are remarkable for the absence of anastomosis. The nerves, as they lie within the vertebral canal, are liable to be compressed from such causes as hydatid and other tumors, by inflammatory products, and by malformation of the vertebral column. As a rule, it may be said that the nerves are more liable to pressure while lying within the vertebral limits than after they escape from them.

The description of the *exvertebral portion* of the nerves includes the remaining peculiarities of the system to which they belong. The general considerations embrace: (*a*) their method of subdividing; (*b*) their method of union in the formation of plexuses and their branches; and (*c*) their topographical position. The spinal nerves, immediately after their escape from the intervertebral foramina, divide into anterior and posterior branches. The anterior (ventral) branches are, except in the case of the first and second cervical nerves, the larger of the two, and supply the ventral aspect of the vertebral column, the sides of the trunk and the limbs. The posterior (dorsal) branches supply the post-vertebral muscles and the occiput. Soon after each nerve escapes, a filament from the anterior division joins the sympathetic. A branch from the nerve in this way constituted returns to the vertebral canal, and supplies the anterior wall and the vertebral vein there situated.

The anterior branches exhibit a disposition to form plexuses, of which five may be separately described: the cervical, the brachial, the lumbar, the sacral, and the coccygeal. The object of a plexus is to secure to a given organ or surface a channel by which it can communicate with the spinal cord, at more than a single segment or level. It has been found by J. Peyer[1] and W. Krause,[2] that each motor nerve,

[1] The term origin is here used conventionally; the posterior root proper *ends* in the spinal cord, see p. 466.

[1] Zeitsch. f. rat. Med., iv., 1853, 52.

[2] Beiträge zur Neurolog. der oberen. Ext., 1865.

after it has left a plexus, consists of more than a single division, and may have as many as three divisions. That is to say, it receives filaments from three separate spinal nerves. Türck[1] has found that sensory nerves supplying skin surfaces of the neck and the lower part of the trunk of the dog are derived from single spinal nerves, while skin surfaces of the extremities were supplied by more than one root.

J. F. Walsh has analyzed the nerves arising from the brachial plexus in man, and has traced each nerve through the plexus to the corresponding spinal nerves, as Féré has done for the nerves of the sciatic plexus. As a rule, it may be said that the most intimate and constant parts of a plexus are those parts which supply nerves yielding both motor and sensory branches. Thus, the upper branches of the lumbar plexus, which are entirely cutaneous, are more variable than the lower, which are musculo cutaneous.

The general significance of a root plexus[2] has been well described by Sir Chas. Bell as follows:—

Whenever nerves are traced it is found that, before entering the muscles, or diverging to the skin, they interchange branches, and form a plexus. This plexus is intricate in proportion to the number of the muscles supplied, and to the variety of combinations into which they enter. Thus, by the interchange of filaments, the combination among the muscles is formed; not only are the classes of extensors and flexors represented in the plexus, but all the varieties of combination are there formed, and the curious relations established which exist between opposing muscles, or rather between the contraction of one class and the relaxation of the other.[3]

According to Nuhn, the relation of the places of exit of different spinal nerves to the skull and to the vertebræ is the following:—

1st Cervical Nerve—border of foramen magnum.
8th " " —opposite spine of the sixth cervical vertebra.
6th dorsal " —between spines of 4th and 5th dorsal vertebræ.
12th " " —opposite spine of 10th dorsal vertebra.
5th lumbar nerve—opposite lower half of spine of 12th dorsal vertebra.
5th sacral " —level of upper half of spine of 1st lumbar vertebra.

The *Variations* in the spinal nerves, in addition to the facts noted on p. 461, are, a disposition to union after division by which "island-formations" are made, which resemble those already described in connection with the bloodvessel system. Variations in nerves, bloodvessels, and muscles of the same region not infrequently coexist.[1] The lower portions of plexuses are apt to present larger ranges of variety than the upper portions. The nerves on the dorsal surfaces of the hand and the foot are more variable than are those on the palmar and plantar surfaces. Sensory nerves anastomose among themselves more frequently than do motor nerves. It follows that losses of motion after section of a given nerve-trunk are more constant than are losses of sensation.

It is in addition found that nerves anastomose more frequently as they approach the distal extremity of a limb than they do at any other part.

In connection with this, the following reflection may prove of service: the relative degree of the strength of muscles is to be measured, not only by the power of the muscle in health, but by its capacity to resist the encroachments of disease. In this sense the Sartorius, the Supinator Longus, the Extensor Carpi Ulnaris, and the Extensor Indicis, are strong muscles, since they are apt to remain intact; while other members of the group to which they belong become palsied, as in muscular atrophy and in palsy from lead poisoning; while the Deltoid is a weak muscle, since it readily becomes paralyzed after injury or lead-poisoning.

Nerves, while divided physiologically into motor and sensory, cannot be distinguished as such by any structural test. The fibres of the spinal nerves after the union of the two roots are inextricably associated. In the manner by which branches are given off, however, it may be seen which nerves are for the most part motor, and which are sensory. The sensory nerves tend to be superficial, and are distributed to subcutaneous and cutaneous surfaces; while the motor nerves are distributed to muscles. The motor nerves are apt to be smaller and less numerous than the sensory. It is owing to

[1] Sitzsungb. d. Wiener Acad., 1851.

[2] Plexuses have been assigned by Schwalbe to three groups: the *root plexuses*, composed of anterior branches of spinal nerves; *trunk plexuses*, which are composed of island-like formations on the trunk of a single nerve, as the œsophageal plexus of the pneumogastric nerve; and the *terminal plexuses*, which relate to the union of nerves just before their final distribution.

[3] This fact appears to have been established as early as 1824, by Sir Chas. Bell (Exposition of Nerves of the Human Body, 362), whose language has been retained in part in the above paragraph.

[1] The correlations existing between the variations of the great sciatic nerve and the Pyriformis muscle; the range of variation between the Brachialis Anticus and the Supinator Longus muscles, correlating with the effects of localized atrophy of the muscles of the superior extremity, will serve as illustrations of this topic.

the fact that the sensory are also the superficial nerves that inflammatory processes of the fasciæ, especially about the joints, often involve nerve-trunks, and give rise to much pain; and the pain attending passive motions of joints arises from the fixation by lymph-bands of sensory nerves along the lines of contractions or forced joint-movements. In the same manner, it can be explained why persistent reflex phenomena may follow upon sharp blows over regions supplied by sensory nerves, upon the pressure of tight-fitting shoes, upon nicking of the cutaneous nerves at the elbow in venesection, etc.

Nerves are best studied for clinical purposes not so much in connection with their indirect relations to adjacent structures, as with the organs to which they are distributed, and with the reflex phenomena elicited through the complicated coördinations into which they enter.

THE CERVICAL NERVES.

The nerves as they escape from the spinal cord pass horizontally outward, and effect their exits from the vertebral canal through the intervertebral foramina, excepting the first nerve, which escapes between the atlas and the occiput. The modifications in the shape of the atlas and axis cause some difference in the arrangement of the first and second cervical nerves. Thus, the first leaves the vertebral canal above the atlas, as the vertebral artery enters it. The second escapes behind the atlo-axoid articulation. The last cervical nerve escapes between the last cervical and the first dorsal vertebra.

The cervical nerves are further characterized by escaping at a point above the vertebra of the corresponding name, instead of below, as is the case with the remaining spinal nerves.

The cervical nerves, in common with all spinal nerves, divide into anterior and posterior branches.

The Posterior Branches of the Cervical Nerves, with the exception of the first, divide into an internal and an external branch.

The first nerve (often called the suboccipital), being in this way peculiar, may be first considered. It passes beneath the second flexure of the vertebral artery, and divides into three branches in the triangular space defined by the Rectus Capitis Posticus Major and the Superior Oblique muscles. It supplies these muscles as well as the Rectus Capitis Posticus Minor, and the Complexus.

The posterior branch of the second cervical nerve (commonly called the *occipitalis major*) passes upward to the occiput, where it pierces the tendinous insertion of the Trapezius, and is distributed to the pericranium and the scalp as far as the parietal eminence. Before becoming superficial, the nerve lies at first upon the Inferior Oblique muscle, and afterward upon the Rectus Capitis Posticus Major, which muscles it supplies, as well as the Biventer and Complexus, and sends a small branch to join the third cervical nerve.

In order to establish the exact position of the superficial portion of the nerve, it is well to remember that it pierces the Trapezius half an inch from the median line, and that it lies generally on a line drawn horizontally from a point ten lines below the external occipital protuberance. These distances are variable within a small range. The occipital artery often passes through the same opening as the nerve; or the artery may be accompanied with a small twig of the nerve. The artery inclines to the median line, the nerve away from it. Where they cross, the nerve is the more superficial.

The fibrous tissue surrounding the nerve at its passage from the deep structures of the neck, may, by induration, act as an exciting cause of neuralgia along the course of the nerve.

The remaining nerves pass over the tips of the transverse processes between the Semispinalis and the Transversalis Cervicis muscles. The external branches are for the most part distributed to these muscles. The internal branches pierce the tendinous origin of the Trapezius from the third, fourth, and fifth nerves to supply the skin, while the sixth, seventh, and eighth end in the Complexus, Semispinalis, and Multifidi Spinæ muscles.

Variations.—The posterior root of the first cervical nerve may contain a small gangliform enlargement. The occipitalis major may yield an auricular branch.

THE CERVICAL PLEXUS.

THE ANTERIOR BRANCHES OF THE CERVICAL NERVES.

The cervical plexus is composed of the union of the anterior branches of the first four cervical nerves. These are, for the most part, smaller than the posterior branches, in this manner not conforming to the rule. The posterior branches of the first and second nerves are of unusual size for posterior spinal branches. They are described above.

The anterior branches of the first four spinal nerves form anastomotic loops with one another, and with the first cervical sympathetic ganglion, to form a loose plexus of branches, which is situated between the Rectus Capitis Anticus Major on the inner side, and the Splenius Colli, Levator Anguli Scapulæ, and Scalenus Posticus muscles on the outer. In front

lies the internal jugular vein. The plexus gradually increases in size from above downward. With the exception of the two lower nerves, it is in relation with the vertebral artery in front.

The fourth and fifth cervical nerves may unite with the plexus on the inferior thyroid artery.

The first cervical nerve is small, and divides into five branches. One of these ascends to join the sympathetic nerve; one passes downward to enter the sheath of the hypoglossal nerve; one usually joins the pneumogastric; while the remainder supply the prevertebral muscles in the neighborhood.

The second cervical nerve supplies the Rectus Capitis Anticus Major, sends an anastomotic branch which aids in forming the Occipitalis Minor, as well as a third which apparently joins the hypoglossal nerve. The descendens noni branch of the hypoglossal nerve is in reality the last-mentioned branch, which, entering the sheath of the hypoglossal, escapes thence to descend the neck (see p. 541). It usually lies over the common carotid artery, but may be over the external carotid artery.

Hilton found, in a case of cut-throat, that the second cervical nerve was paralyzed.

The third cervical nerve is larger than the above. It sends muscular branches to the Levator Anguli Scapulæ, Splenius Colli, Scalenus Medius, and Sterno-Cleido-Mastoid muscles. The branch to the last-named muscle is often in part anastomotic with the spinal accessory. It also effects an anastomosis with the descendens noni from the hypoglossal nerve.

A branch of connection between the first and second nerves is united to the descendens noni from the hypoglossal by a small branch termed the *communicans noni* (see p. 541). The somewhat plexiform arrangement of these nerves has received the name of the *ansa hypoglossi*, from which branches descend to supply the infrahyoid group of muscles (q. v.).

The Branches of the Cervical Plexus are superficial and deep.

THE SUPERFICIAL BRANCHES OF THE CERVICAL PLEXUS.

The Superficial branches of the Cervical Plexus are—

The Superficial Cervical Nerve.
The Great Auricular Nerve.
The Small Occipital Nerve.
The Supraclavicular Nerves.
The Phrenic Nerve.

The Superficial Cervical Nerve arises from the second and third cervical nerves. It winds round the outer border of the Sterno-Cleido-Mastoid muscle, and passes across its belly and beneath the Platysma Myoides, to near the hyoid bone. Of its two terminal branches, the upper is the larger. This upper branch joins one of the cervical branches of the facial, and is distributed to the upper portion of the Platysma Myoides; the lower divides into several delicate filaments, which are distributed to the lower portion of the same muscle.

The Great Auricular Nerve arises from the third nerve. It winds round the outer border of the Sterno-Cleido-Mastoid muscle, and ascends upon this muscle with an inclination forward, to reach the posterior surface of the auricle, which surface it supplies throughout its entire length. Many of the terminal twigs supply the skin posteriorly, while others pierce the cartilage to supply the anterior surface. Before reaching the ear, a delicate branch passes forward and upward to join the facial nerve over the parotid gland. A small branch supplies the lobule of the auricle and the parotid gland in the neighborhood. Posterior to the auricle, branches join the small occipital nerve and the posterior auricular branch of the facial nerve. The great auricular nerve lies beneath the deep fascia, to the outer side of the external jugular vein, and is covered by the Platysma Myoides.

It often divides into branches immediately after appearing from beneath the Sterno-Cleido-Mastoid muscle.

The Small Occipital Nerve arises from the second cervical. It is seen to the outer side of the Platysma Myoides muscle, a little above the auricularis magnus nerve. It ascends the neck in an oblique direction, lying upon the Splenius Capitis, and parallel to the posterior border of the Sterno-Cleido-Mastoid muscle. Piercing the deep fascia, it enters upon the mastoid region.

It here is distributed upon the scalp and joins the posterior auricular branch of the facial, the great auricular, and great occipital nerves. The posterior belly of the Occipito-Frontalis and the Retrahens Aurem often receive filaments from this nerve. The nerve is purely sensory.

Variations.—The nerve may be double, and pierce the lateral border of the Sterno-Cleido-Mastoid muscle or the anterior border of the Trapezius muscle. A descending twig often joins the spinal accessory nerve. According to Cunningham,[1] it gives branches over the parotid, masseteric, and buccal regions, and reaches points as far forward as the angle of the mouth and external canthus.

[1] Journ. of Anat. and Phys., vii., 1873, 97.

The Supraclavicular Nerves are commonly three in number. They arise from the third and fourth cervical nerves, and make their appearance to the outer side of the Sterno-Cleido-Mastoid muscle, about on the level of the thyroid cartilage. All of the three groups of nerves are directed downward, and, diverging from one another, are distributed to the superficial parts of the root of the neck, and the upper portion of the thorax. The median pass downward along the outer border of the Sterno-Cleido-Mastoid muscle to its origin from the clavicle. Their branches are distributed to the skin over the sterno-clavicular articulation, to the joint itself, to the sternal fibres of the Pectoralis Major muscle, and to the Platysma Myoides. These nerves cross the external jugular and transversalis cervicis veins. The middle branch crosses the clavicle at about its middle, and supplies the skin over the Pectoralis Major, as far as the fourth rib, and joins the cutaneous branches of the intercostal nerves. The lateral (outer, supra-acromial) group of branches descend over the acromial end of the clavicle to the skin over the Deltoid muscle.

THE DEEP BRANCHES OF THE CERVICAL PLEXUS.

In addition to the branches of union with the pneumogastric and sympathetic nerves already noted, and the apparent union with the hypoglossal nerve, the deep branches supply the prevertebral muscles, the Scaleni, the Levator Anguli Scapulæ, and the Trapezius muscles.

The Phrenic Nerve (internal respiratory nerve of Bell) is the most important of the deep branches of the cervical plexus. It arises from the fourth cervical nerve, receives a communicating branch from the third or the fifth, and, as a rule, another from the inferior cervical ganglion of the sympathetic. It is the nerve of motion to the Diaphragm, and of general sensation to the peritoneum in part. The nerve passes obliquely downward and inward over the Scalenus Anticus muscle, and, reaching the base of the neck, lies between the subclavian artery and the subclavian vein near the junction of the latter with the internal jugular vein. As the nerve enters the thorax it receives filaments from the sympathetic and lies to the median side of the internal mammary artery. Within the thorax the nerve passes downward in front of the root of the lung, and by the side of the pericardium to the Diaphragm, which it pierces to supply the under surface. It lies close to the pericardium, inclosed by the pericardiac pleura, and is in company with the pericardio-phrenic artery and vein. Filaments of the nerve can be traced in the peritoneum as far as the umbilicus. Among other relations it passes to the outer side of the ascending cervical artery, and is crossed by the transverse cervical and posterior scapular arteries.

The courses of the right and left nerves are not in all respects alike. The *right phrenic nerve* is somewhat shorter and more deeply situated than the left, by reason of the greater elevation of the right half of the diaphragm. It lies to the right side of the right innominate vein and of the superior vena cava before this vessel enters the pericardium. The *left phrenic nerve* passes downward and inward from the corresponding pneumogastric nerve in front of the end of the aortic arch and the pulmonary artery.

Variations.—The following include the variations in the composition of the phrenic nerve. A branch from the brachial plexus to the Subclavius muscle often joins the phrenic; a branch from the middle cervical ganglion of the sympathetic sometimes joins a branch from the phrenic as it lies between the fourth and fifth cervical nerves, the nerve thus formed supplying the walls of the transversalis colli artery; it may receive twigs (communicantes phrenici) from the fifth and sixth cervical nerves; instead of the above, an *accessory phrenic* nerve may be formed by the union of the fifth and sixth cervical nerves, or may arise from the fifth alone. The accessory phrenic passes downward on the Scalenus Anticus muscle to the outer side of the mammary artery to join the phrenic nerve at the root of the neck, or in the thorax near the origin of the innominate artery. The phrenic often receives a branch from the descendens noni.

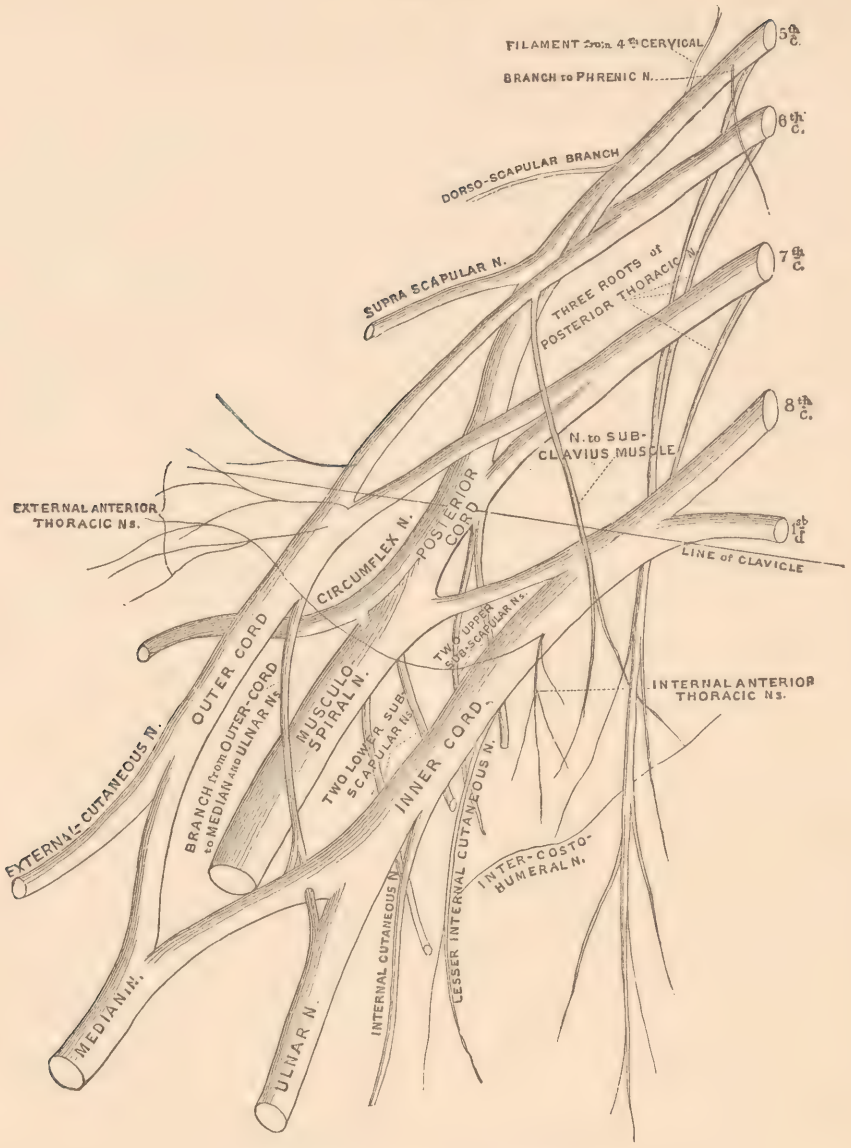
Among the variations of distribution may be mentioned a branch which supplies the Anterior Scalene muscles, and divides into two branches, between which the internal mammary artery passes.

In variations of relation the nerve may lie along the outer edge of the Scalenus Anticus muscle under the transversalis colli and supra-scapular arteries, and the junction of the internal jugular and subclavian veins. It may enter the thorax in front of the brachial plexus, and of the subclavian and innominate veins, or it may cross the internal mammary artery at its origin.

Remarks.—The clinical applications of a knowledge of the phrenic nerve relate to the nature of various reflex phenomena, and to the interference of function of the nerve from pressure, either from a tumor or other cause.

It has been seen that the nerve has connection with the sympathetic system and with the brachial plexus of nerves, as well as with other branches of its own plexus, especially the supra-clavicular nerves. Luschka proposes by the aid of such facts to explain the reflex pains in the region of the shoulder in dia-

Fig. 123.



A diagrammatic drawing of the brachial plexus.

phragmatic pleurisy and pericarditis. Probably, the pains in the right shoulder so often found in diseases of the liver have a similar origin. Through the peritoneal filaments it is thought the pains of peritonitis, and of the early stages of many abdominal diseases, can be in part explained.

The nerve has been found involved in morbid products, such as old tubercular deposits, and may be pressed upon by enlarged lymphatic glands of the anterior mediastinum.

THE BRACHIAL PLEXUS.

The Brachial Plexus is composed of the anterior branches of the four lower cervical nerves and of the first dorsal nerve. It receives a filament from the cervical plexus.

The description of the brachial plexus includes an account of the composition of the "outer cord," of the "inner cord," of the "posterior cord," and of the origins of the nerves of the upper extremity (see fig. 123).

The fifth cervical nerve[1] passes downward and joins a branch of the sixth nerve, the main portion, however, of the sixth nerve passing without division to the outer part of the plexus to form the "*outer* or *upper cord*." The fibres of the fifth nerve do not contribute to the formation of the outer cord, but are continued into the posterior cord. At the point of junction of the fifth and sixth nerves a branch arises that assists in the formation of the "*posterior* or *middle cord*."—The seventh nerve divides into two

[1] It is assumed in each case that it is the anterior division of each nerve that is described.

branches, one of which joins the sixth to complete the composition of the "outer cord," while the other completes the "posterior cord."—The eighth cervical and first dorsal nerves unite to form the "*inner* or *lower cord*," but send an important branch to the posterior cord at its lower part.[1]

The "outer cord" and the "inner cord" are placed anteriorly to the "posterior cord," the three constituting the narrowest part of the plexus. From the distal ends of the "outer cord," and the "inner cord," the external cutaneous, median, ulnar, internal cutaneous, and lesser internal cutaneous nerves arise; from the distal end of the "posterior cord," the musculo-spiral nerve, and the circumflex nerve arise.

The arrangement of these nerves is as follows: The "outer cord" divides into two branches, the outer forming the *trunk of the external cutaneous nerve* (*musculo-cutaneous*), while the inner forms the *outer root of the median* nerve. The inner cord also divides into two branches, one of which completes the formation of the *median*, and the other forms the *ulnar* nerve. The ulnar nerve further receives a branch from the inner aspect of the outer cord, which pierces the inner root of the median to reach the ulnar nerve. The inner cord gives off from the median side the *internal cutaneous nerve*, and the *lesser internal cutaneous nerve* or nerve of Wrisberg. The posterior cord is continued for the most part directly into the *musculo-spiral nerve*, but yields the important *circumflex nerve* from its lateral border.

The following table exhibits the arrangement of the brachial plexus and its branches:—

Outer Cord.

Composed of	Yields
Portion of Sixth Cervical Nerve,	External Cutaneous,
Portion of Seventh Cervical Nerve,	Outer Root of Median, Accessory Branch to Ulnar.

Inner Cord.

Composed of	Yields
Eighth Cervical Nerve, First Dorsal Nerve,	Internal Cutaneous, Lesser Internal Cutaneous, Ulnar, Inner Root of Median.

Posterior Cord.

Composed of	Yields
Branch of Fifth and Sixth Cervical Nerves, Portion of Seventh Cervical Nerve, Branch from Eighth Cervical Nerve and from First Dorsal Nerve.	Circumflex, Musculo-Spiral.

The origin of the remaining nerves will be described under the appropriate heads.[1]

Variations.—The outer and inner cords more frequently interchange portions of their filaments than do either of these cords with the posterior. Thus the thoracic nerves may range in origin from the outer to the inner, but never from the inner or outer to the posterior cord; and the ulnar nerve may extend its origin to the outer cord, but never to the posterior. The posterior root, on the whole, is the least variable, except as to degrees of fusion existing among its branches, of all of the cords of the plexus.—The seventh cervical nerve may unite without division with the trunk formed by the union of the fifth and sixth cervical nerves. The outer cord may be formed by the sixth and a part of the seventh, the remaining part of the seventh assisting a portion of the eighth in forming the posterior cord. The seventh nerve may not join the upper cord, but may join the inner and posterior cords, and aid in forming the median nerve.—The ulnar, internal cutaneous, and lesser internal cutaneous nerves may arise from the seventh cervical nerve; and the circumflex and the musculo-spiral arise from the seventh and the eighth.—A portion of the plexus may go between the two Scalene muscles, another may go in front of the Scalenus Anticus, while yet a third may pierce the latter muscle. All the nerves of the brachial plexus may run above the axillary artery.

Some of the variations of the brachial plexus will be treated under the heads of the nerves arising from the plexus.

Remarks.—The fifth, sixth, and seventh cervical roots were excised by H. B. Sands[2] for neuralgia of the upper extremity. The following was the method pursued by the operator in this case. A rectangular incision was made, its long arm extending parallel to the outer border of the Sterno-Cleido-Mastoid muscle, and its shorter arm following the clavicle. The flap was then raised, and the connective tissue, with fibres of the Platysma Myoides and the clavicular portion of the Sterno-Cleido Mastoid muscle, divided. The external jugular vein was drawn outward, and on a plane a little deeper than this vessel the

[1] The following arrangement of the roots of the brachial plexus is described by some writers:—

The fifth and sixth nerves unite into a common trunk. The seventh nerve unites with this, and the three thus form the "outer cord." The eighth cervical and first dorsal nerves unite to form the "inner cord." As these two main cords reach the clavicle, each gives off a branch, and by the union of these branches the "posterior cord" is formed.

[1] The above description is largely based upon the results of a series of dissections made by J. F. Walsh, Am. Journ. Med. Sci., 1877, 389, fig.

[2] Archives of Scientific and Practical Medicine, i., 1873, 1.

nerves were exposed. An examination of the amputated limb showed the median, external-cutaneous, and ulnar nerves in a state of degeneration. F. F. Maury[1] divided the outer and inner cords of the plexus in a man suffering from painful multiple neuroma of the upper part of the arm. Partial relief of the affection ensued.

By the disposition of the cords in the axilla the nerve-trunks and the axillary artery are intimately associated, and form what writers on surgical anatomy have called a vasculo-nervous cord.[2] The pressure of the head of a crutch, or similar pressure caused by sleeping with one arm thrown over the top of a chair, or by the act of raising a child from the ground by the extended arm, may excite so much disturbance within the nerves of this cord, if not doing actual injury to the nerve-fibres themselves, as to lead to paralysis of all the muscles of the exserted portion of the arm, and in some instances to permanent wasting and disuse.

In long-standing dislocation of the shoulder-joint, the cords of the brachial plexus may be firmly bound to each other and to the head of the humerus by the results of inflammatory infiltration. It is evident that, with these conditions present, laceration of the nerves must be added to the danger to the blood-vessels, following violent movements of the arm in attempts to reduce the dislocation. In connection with this, Flaubert reports a case in which the spinal attachments of the plexus were actually severed.

Israel[3] describes a case of gunshot wound of the left shoulder which involved the median and ulnar nerves. The proximal ends of these nerves united one to the other, while the distal portions atrophied.

J. Hutchinson[4] reports a case of injury to the brachial plexus in which all parts of the limb were paralyzed, except those supplied by the intercosto-humeral nerve. A second case is reported by him,[5] in which all the muscles of the arm and forearm were paralyzed, excepting the rotators of the humerus, the Triceps, Biceps, Brachialis Anticus, Coraco-Brachialis, and the upper part of the Pectoralis Major. No sensation existed below the elbow, and impaired sensation only was present over the upper arm.

From the dissections of the human subject by J. F. Walsh, and the experimental researches of D. Ferrier and B. Yeo on the monkey, the following may be said to embrace what is known of the significance of the roots of the brachial plexus.[1]

The ulnar nerve, the internal cutaneous nerve, and the lesser internal cutaneous nerve, are continuous wholly or in part with the *first dorsal nerve.* The median and the musculo-spiral are also derived from this nerve in part. Stimulation of the nerve causes contraction of the intrinsic muscles of the hand, such as the muscles of the ball of the thumb, the Interossei, etc.

The ulnar, internal cutaneous, musculo-spiral, and median derive fibres from the *eighth cervical nerve.* Stimulation causes flexion of the fingers with pronation and ulnar flexion of the wrist, and retraction of the arm with extension of the forearm.

The ulnar, median, and musculo-spiral commonly receive filaments from the *seventh cervical nerve;* as do, rarely, the circumflex and external cutaneous nerves. Stimulation of the trunk causes adduction, rotation, and retraction of the upper arm, extension of the forearm, and flexion of the wrist and fingers so as to bring the tips against the flank.

The circumflex, external cutaneous, median, supra-scapular, and musculo-spiral nerves derive filaments from the *sixth cervical nerve.* Stimulation of the sixth cervical nerve causes adduction and retraction of the upper arm, extension of the forearm, and pronation and flexion of the wrist, the palm being brought toward the pubes.

The circumflex, external cutaneous, median, and musculo-spiral nerves derive filaments from the *fifth cervical nerve.* Stimulation causes elevation of the

[1] Report by L. Duhring, Am. Journ. Med. Sci., lxviii., 1874, 29.

[2] E. Bellamy, Med. Times and Gaz., 1879, 473.

[3] Virchow's Archiv, 1880, lxxxv. 1.

[4] Illus. of Clin. Surg., i. 1875, 206.

[5] Trans. Path. Soc. Lond., 1880, 27.

[1] While it is acknowledged that such a scheme leaves some facts unexplained, its several parts are harmonious. The results of experimentation must of necessity be imperfect, for the differences between the arm of the monkey and the arm of the human subject will be expressed in its movements under the stimulation of the complex nerves controlling its muscles.

EXPLANATION OF PLATE LXXXV.

Fig. 1. A dissection exhibiting the superficial nerves of the face and the neck.

Fig. 2. A dissection exhibiting the deep cervical nerve and the brachial plexus.

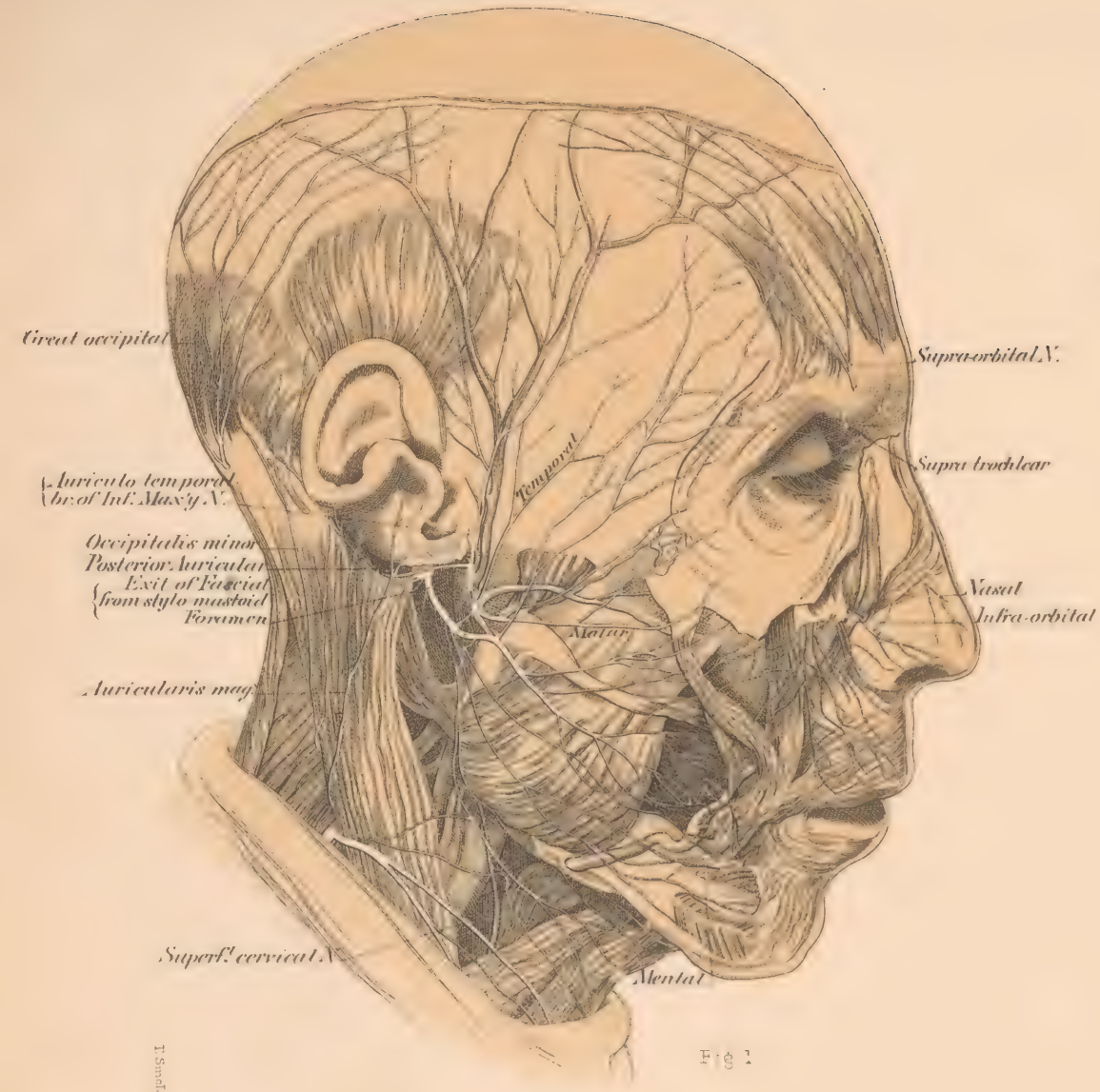


Fig 1

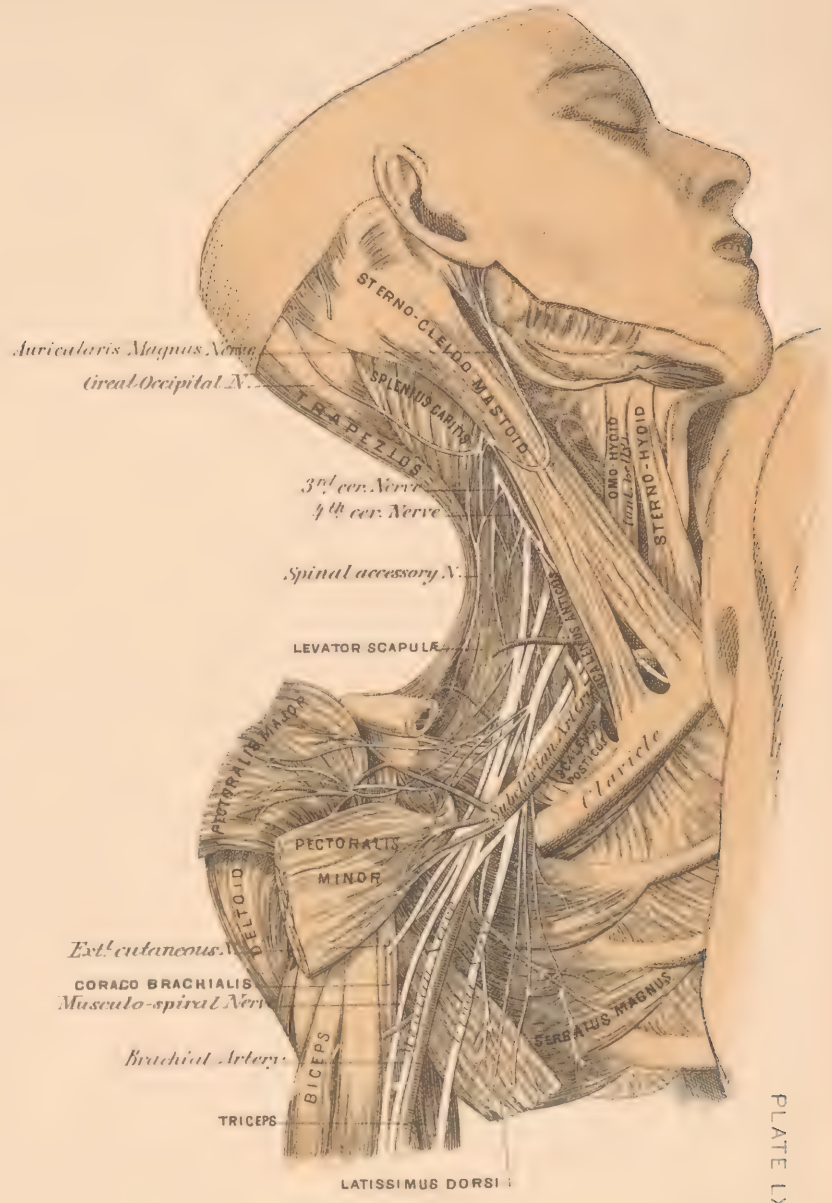


Fig 2

PLATE LXXXV

T. Sinclair & Son Lith.

upper arm inward, with supination and flexion of the forearm, and extension of the wrist and fingers.

The dorsal scapular secures its filaments from the *fourth cervical nerve*. Stimulation causes elevation of the arm with a backward movement, the forearm and hand remaining as in the preceding act.

Eisenlohr[1] locates the centre in the spinal cord controlling the Triceps and Pectoral muscles, and the extensor muscles of the hand and fingers in the cells connected with the sixth and eighth nerves; and the centre controlling the intrinsic muscles of the hand in those connected with the eighth cervical and first dorsal nerves.

The Branches of the Brachial Plexus.[2]

Trunkal,	to Scalenus Anticus. to Scalenus Medius. to Scalenus Posticus. to Longus Colli. Communicans Phrenici.
Supplying the Extrinsic Muscles of the Superior Extremity,	Dorsal Scapular. Subclavian. Anterior Thoracic. Posterior Thoracic. Circumflex.
Supplying the Intrinsic Muscles of the Superior Extremity,	Suprascapular. Subscapular. Median. Musculo-Spiral. External Cutaneous. Ulnar. Internal Cutaneous. Lesser Internal Cutaneous.

[1] Neurolog. Centralblatt, No. 18, 1882.

[2] The methods of arrangement proposed for the branches of the brachial plexus have lacked uniformity. C. Krause has divided them topographically by the position of the clavicle. Thus the posterior thoracic, the suprascapular, the dorsal scapular nerve, the Subclavian nerve, the branches for the Longus Colli, and the occasional branch to the phrenic, form the *supra-clavicular group;* while all the remaining branches of the nerve constitute the *infra-clavicular group*. This method has been followed by English writers. Cruveilhier names the branches to the muscles about the shoulder the *collateral*, and those pertaining to the exserted portion of the limb the *terminal* branches. Arnold divides the nerves into the nerves of the shoulder, those of the thorax, and those of the scapula, while the remaining nerves he calls the brachial. Henle retains the term "short nerves" for those of the muscles of the shoulder, and the term "long nerves" for those of the exserted portion of the limb. Fürbringer proposes to divide the branches into dorsal and ventral groups, with respect to the axis of the limb. The *dorsal group* is subdivided into nerves for the shoulder, including the rhomboid and supra-spinatus, the circumflex, the posterior thoracic, and subscapular nerves; and those nerves for the exserted portion of the limb, including the musculo-spiral nerve. The *ventral group* is in its turn subdivided into nerves for the shoulder, including the branch to the Scalene, Longus Colli, and Subclavius muscles, and the anterior thoracic; and those nerves for the flexor muscles of the exserted portion of the limb, which embrace the median, ulnar, external cutaneous, internal cutaneous, and intercosto-humeral nerves. To properly assign the planes of dorsum and venter, Fürbringer abducts the limb and turns the palm forward. But this is a position as conventional as the one usually assumed, viz., with the limb pendent and the palm turned forward. The terms flexion and extension, as used by Fürbringer, would not apply to the Lumbricales, nor to the Interossei, which are supplied by the ulnar (or flexor) nerve.

All classifications agree in placing the nerves of the trunk in a group separate from those of the arm, excepting that of C. Krause, which, nevertheless, excludes some of the thoracic nerves. The classification employed in the text is based upon the groupings of the muscles to which the nerves go; for the study of nerves and the parts supplied by the nerves is held to furnish a better standard for classification than any groupings of the nerves according to their respective lengths or to regions defined by the standards of topographical anatomy.

The Trunkal Branches of the Brachial Plexus arise from the lower cervical nerves, close to their exits from the intervertebral foramina, and supply the distal portions of the Scalenus Anticus and Scalenus Medius muscles, as well as the Scalenus Posticus and the distal portion of the Longus Colli (Schwalbe).

The Branches of the Brachial Plexus supplying the extrinsic muscles of the Upper Extremity include:—

The Dorsal Scapular.
The Subclavian.
The Anterior Thoracic.
The Posterior Thoracic.
The Circumflex.

THE DORSAL SCAPULAR NERVE.

The Dorsal Scapular Nerve (nerve to the Rhomboideus) commonly arises from the fifth cervical nerve, and passes transversely outward through the fibres of the Scalenus Medius, to reach the Rhomboideus muscle. Some of its fibres pierce the Rhomboideus, and are lost in the Trapezius, while others, as a rule, supply the Serratus Posticus Superior. It often unites with the highest root of the posterior thoracic nerve.

It may give a branch to the Levator Anguli Scapulæ. The Rhomboideus muscle may be supplied in addition by filaments from the second and third dorsal nerves.

THE SUBCLAVIAN NERVE.

The Subclavian Nerve, the smallest of the branches, arises from the anterior aspects of the cord formed by the union of the fifth and sixth cervical nerves. It passes in front of the axillary artery and vein, to reach the Subclavius muscle. It is often united to the phrenic by a small filament.

THE ANTERIOR THORACIC NERVES.

The Anterior Thoracic Nerves, of which there are two, an external and an internal, supply the pectoral muscles. The *external* (lateral) arises from the outer cord of the plexus, crosses over the axillary vessels, and supplies the Pectoralis Major muscle. The *internal* (median) comes from the inner cord, passes between the artery and vein to reach the under surface of the Pectoralis Minor, to which it gives branches, and finally joins the external branch. Its branches form a loose open plexus among themselves, which sends a small twig to the walls of the arteries of the pectoral group of muscles. The lateral set can be traced to the fifth, sixth, and seventh cervical nerves; the median set to the eighth cervical and the first dorsal nerve.

Variations.—The external anterior thoracic nerve may supply the clavicular portion of the Deltoid muscle. The nerve to the Pectoralis Minor may be an independent branch, and may in addition supply the shoulder-joint.

THE POSTERIOR THORACIC NERVE.

The Posterior Thoracic Nerve (external respiratory nerve, long thoracic nerve) arises by filaments from the posterior part of the fifth and sixth cervical nerves within the Scalenus Medius muscle. It passes downward in front of the Scalenus Posticus, and afterward lies between the Subscapularis and the Serratus Magnus muscles. It is distributed to the latter muscle, sending a separate twig to each of the digitations.

Variations.—The roots of the nerve may remain separate until the level of the clavicle is reached. The nerve may arise from three roots. The branch to the upper digitations of the Serratus Magnus may be independent, and arise from the fifth cervical nerve.

Remarks.—Birkett[1] reports a case of sero-sanguineous cyst of the neck and the axilla, in which the posterior thoracic nerve was involved. The removal of the cyst was followed by a vesicular eruption over the corresponding arm.

E. Bellamy[2] has observed that after deep axillary abscess, which occasionally follows partial destruction of the Serratus Magnus and the connective tissue thereabout, the ensuing cicatrization may involve the posterior thoracic nerves, and a partial paralysis result. This is remediable, and the function of the Serratus Magnus may be in the main restored.

[1] Med. Chir. Trans., li.

[2] Medical Times and Gazette, 1879, p. 473.

A gunshot wound of the Pectoralis Major muscle, in a remarkable case observed by S. W. Mitchell,[1] was followed by paralysis of the anterior thoracic, external cutaneous, median, and circumflex nerves.

THE CIRCUMFLEX NERVE.

The Circumflex Nerve supplies the Deltoid, the Teres Minor, the third head of the Triceps, the skin of the arm over the Deltoid muscle, and the shoulder-joint. It arises from the posterior cord of the brachial plexus in common with the musculo-spiral. It lies behind the axillary artery, and, descending a short distance in front of the Subscapularis muscle, enters the space between the Teres Minor and Teres Major muscles, to the outer side of the long head of the Triceps, in company with the posterior circumflex artery. Passing around the surgical neck of the humerus, it reaches the under surface of the Deltoid muscle, within which it is in great part distributed. The terminal fibres are at first protected by a layer of fibrous tissue, but the filaments soon enter the Deltoid muscle, and some of them penetrating it supply the skin. A branch which possesses a gangliform enlargement supplies the posterior border of the Deltoid muscle and the Teres Minor.

A cutaneous branch, which often arises in common with the preceding, passes between the posterior border of the Deltoid and the long head of the Triceps, pierces the fascia, and supplies the skin over the Deltoid and the Triceps. Several articular branches arise from the trunk of the nerve and supply the front and back parts of the shoulder-joint. A constant branch runs along the outer border of the bicipital groove, giving branches to the bone and to the sheath of the tendon of the Biceps, and apparently ending in the capsule.

The nerve rests upon the Subscapularis muscle beneath the musculo-spiral, and turns round the inferior border of this muscle beneath the subscapular artery.

Variations.—The circumflex nerve often arises in common with the lower subscapular nerve. It may infrequently arise from the seventh and the eighth cervical nerves. It may arise beneath instead of from the lateral surface of the posterior cord. It may send a branch to the Teres Major.

Remarks.—Since the chief function of the circumflex nerve is to supply the Deltoid muscle and the skin over it, it is rational to include it among the extrinsic nerves, since the muscle itself is a member of the extrinsic group. It is interesting to note the fact that the filaments of the nerve can be traced to the upper nerves of the brachial plexus, thus indicating

[1] Injuries of the Nerves.

the functional relation the nerve holds to the cervical plexus.—The functions of the Deltoid and Rhomboid muscles, and the motion of outward rotation of the humerus, are often conjointly impaired.—The nerve may be independently paralyzed in lead palsy, or it may be paralyzed in conjunction with the extensors of the forearm, hand, and fingers, a combination recalling the association of the circumflex and musculo-spiral nerves in the posterior cord of the brachial plexus.

The origin of the nerve being in the upper portion of the plexus, blows at the base of the neck may involve it, and atrophy of the Deltoid ensue, while the muscles supplied by the median, musculo-spiral, and external cutaneous nerves escape. Owing to its relation to the capsule of the shoulder-joint, the circumflex nerve is liable to injury in dislocation of the head of the humerus into the axilla.

The Branches of the Brachial Plexus supplying the Intrinsic Muscles of the Upper Extremity include—

The Suprascapular.
The Subscapular.
The Ulnar.
The Internal Cutaneous.
The Lesser Internal Cutaneous.
The Median.
The Musculo-Spiral.
The External Cutaneous.

THE SUPRASCAPULAR NERVE.

The Suprascapular Nerve (the nerve of the suprascapular muscles) arises from the upper portion of the brachial plexus, at the outer side of the "outer cord," which is formed by the union of portions of the sixth and seventh cervical nerves. It passes backward, downward, and outward beneath the Trapezius, and crosses the origin of the Omo-Hyoid muscle to reach the suprascapular notch, through which it passes in company with the suprascapular artery, and, passing outward along the supraspinous fossa, enters the infraspinous fossa by winding around the outer concave border of the spine of the scapula.

The nerve supplies the Supra-Spinatus and Infra-Spinatus muscles, and, according to Hyrtl, the Teres Minor as well. It occasionally sends branches to the capsule of the shoulder-joint. Henle states that it sometimes gives a branch to the Scalenus Medius.

Luschka considers the suprascapular nerve to be purely motor. It may arise from the fifth cervical nerve.

THE SUBSCAPULAR NERVES.

The Subscapular Nerves, three in number, supply the muscles of the same name, and arise from the posterior cord of the plexus. Two of the three are distributed to the Subscapular muscle, the first supplying the upper, the second the lower portion in conjunction with the Teres Major. The remaining nerve (long subscapular, lower subscapular) extends along the lower border of the Subscapularis muscle, parallel with the long thoracic nerve, to supply the Latissimus Dorsi. A small nerve, distinct from the above, enters the Subscapularis at its upper portion. It is a separate branch of the brachial plexus, and arises above the clavicle. It supplies the walls of the subscapular artery.

Variations.—The subscapular nerves may be four and even five in number. The lower subscapular often arises in common with the circumflex nerve.

THE ULNAR NERVE.

The Ulnar Nerve arises from the inner cord of the brachial plexus in common with the internal cutaneous nerve. It is smaller than the median, and placed somewhat between that nerve at its origin and the musculo-spiral nerve. The trunk at first lies parallel to the median nerve to its inner side, but toward the elbow it is deflected backward and pierces the internal intermuscular septum, behind which it lies in company with the inferior profunda artery. Thence the nerve winds round the epitrochlea on the inner side of the elbow to gain the ulnar side of the coronoid process at which it is lodged between the two heads of the Flexor Carpi Ulnaris muscle. In the forearm it descends in a straight line upon the anterior surface of the Flexor Profundus Digitorum, at first remote from the ulnar artery, but from the middle of the forearm downward parallel to it and lying on the median side. In this relation it reaches the wrist in front of the annular ligament, and divides into its terminal branches on the annular ligament or at a point answering to the distal border of that structure.

The Branches of the Ulnar Nerve are:—

Articular.
Muscular.
Cutaneous.
Palmar.

The ulnar nerve yields no branches above the elbow.

Branches in the Forearm.—In the forearm, directly below the elbow, several small *articular* branches are given off, as well as a *muscular* branch, which supplies the Flexor Carpi Ulnaris, reaching it from its under surface. Several smaller nerves may take the place of this single branch. Another *muscular* branch goes to the median portion of the Flexor Profundus Digitorum, reaching it from its anterior surface.

About the middle of the forearm two small inconstant *cutaneous* branches perforate the antebrachial fascia, to join the internal cutaneous nerve. A smaller, but more constant, *palmar* branch accompanies the ulnar artery to the palm.

About two inches above the wrist arises the *dorsal cutaneous* branch. It passes obliquely backward and outward between the ulna and the Flexor Carpi Ulnaris to reach the dorsal aspect of the forearm, along which it descends between the last-named muscle and the Extensor Carpi Ulnaris to the head of the ulna, where it divides into two branches, an internal and an external. The *internal branch* passes along the ulnar border of the fifth metacarpal bone, and the corresponding dorsal border of the little finger. The *external*, the larger of the two, sends an anastomotic branch to join the radial nerve, and descends upon the fourth interosseous space, where it divides into two branches, one of which supplies the dorsal surface of the radial side of the fifth finger, the other the ulnar side of the fourth finger.

Branches in the Hand. The branches of the ulnar nerve in the hand are the superficial and the deep.

The Superficial Palmar Branch is commonly smaller than the deep branch, and, passing beneath the Palmaris Brevis, divides near its origin into two portions, one of which passes to the ulnar border of the fifth finger, and to the integument; and the other supplies the opposed sides of the fourth and fifth fingers. The branch last named sends a small twig to the skin of the palm, as far as a line corresponding to the median border of the third finger. The superficial palmar nerve supplies the Palmaris Brevis muscle, the fourth Lumbrical, and sometimes the third Lumbrical muscle, and anastomoses with the digital branches of the median nerve.[1]

The Deep Branch follows the course of the deep palmar artery. To reach its deep position beneath the Flexors of the fingers it penetrates the muscles of the little finger, usually passing between the Abductor Minimi Digiti and the Flexor Brevis Minimi Digiti. It yields branches from the convexity of its curve to the inner two Lumbricals and to all the Palmar and Dorsal Interossei muscles. From its concavity a few inconstant twigs pass to the front of the carpus. In addition it sends branches to the short muscles of the little finger as it passes through them, and terminates in the Adductor Pollicis, in the deep portion of the Flexor Brevis Pollicis, and in the first Dorsal Interosseous muscle.

The ulnar nerve supplies both the superficial and deep palmar arches.

Variations.—The origin of the ulnar nerve from the outer brachial cord is given by many authorities as a variation. The outer root may be traced to the seventh cervical nerve. The nerve may yield a branch above the elbow which may unite with a branch of the internal cutaneous nerve. It may supply in part the Flexor Sublimis Digitorum. The terminal branches may supply both the ulnar and the radial border of the ring finger. Should it fail to reach the dorsum of the hand, its place may be taken by the radial nerve. The third Lumbrical muscle is occasionally supplied by the median nerve. The lesser internal cutaneous nerve often unites with the ulnar nerve. (W. Krause.)

Remarks.—The position of the ulnar nerve back of the epitrochlea; its meagre distribution to the muscles of the forearm, viz., to the Flexor Carpi Ulnaris (a lateral tractor of the carpus rather than a flexor), and the ulnar portion of the Flexor Profundus Digitorum; its distribution to *all parts* of the superficies of the ulnar region of the hand; are facts which sharply distinguish it from the median nerve. At the same time it is well to remark that in the range of variations of the nerve it may supply branches to the Flexor Sublimis Digitorum, thus assisting the median, and that its paralysis may impair the motions of the thumb. In a case reported by Brown-Séquard,[1] the Abductor Pollicis, the lateral head of the Flexor Brevis Pollicis, and the Opponens Pollicis, were atrophied, while the movements of flexion and extension of the wrist and fingers were weak. It is possible that a variation which has not come under the writer's notice may account for the paralysis of the Abductor Pollicis here mentioned.—The nerve is quite compactly invested in the upper arm, but when dissected away from its relations can be drawn well off to the inner side of the arm. An amount of motion takes place in the ulnar nerve which is greater than that in other nerve-trunks. It is relaxed in extension of the forearm, and is tense in flexion. It is doubtless to facilitate this motion that the nerve lies so loosely surrounded by connective tissue behind the epitrochlea. In the aged this connective tissue is often remarkably thickened. E. Zuckerkandl[2] narrates an instance in which, as a result of deformity following fracture, the ulnar nerve lay, during flexion of the elbow-joint, on the anterior

[1] To demonstrate these branches divide the tendons of the superficial and the deep flexors on a line with the unciform bone, and turn them forward. The Lumbricals will be displaced on the under surface of the tendons, and the nerves readily seen.

[1] Archives of Scientific and Practical Medicine, 1873, p. 56.

[2] Wiener med. Jahrbuch., 1880, p. 135.

aspect of the epitrochlea, but during extension slipped back to its normal plane.—The nerve is well protected above the elbow by its deep position among the nerves and vessels with which it is associated, by the internal intermuscular septum and the epitrochlea, and in the forearm by the Flexor Carpi Ulnaris. Its most exposed situation is where it crosses the annular ligament.

Blows over the ulnar nerve, as it lies behind the epitrochlear process, may be followed by tingling pains throughout its distribution. The nerve in the same situation has been accidentally divided during the operation of excision of the elbow-joint.—The nerve may be injured by blows over the lower part of the humerus.—The tract of the ulnar distribution may be the seat of a neuralgia following a blow over the region of the plexus *above* the clavicle. In a case reported by S. W. Mitchell[1] it was believed that, notwithstanding the exact limitation of the neuralgia, no portion of the ulnar nerve had been injured. Following injury to the nerve, successive crops of vesicles may arise over the course of distribution of the cutaneous filaments.—Dupuytren records a case in which the end of a whip-lash was found imbedded in the nerve.

J. Hilton[2] gives the following interesting example of the effects of pressure upon the left ulnar nerve. A woman, forty-seven years of age, suffered from persistent pressure on the trunk of the ulnar nerve, excited by an exostosis which grew from the first rib. The subclavian artery was also occluded. Numbness of the third and fourth fingers with pain had been complained of for a year, followed by enfeebled motion of the fingers, and gangrene of the ends of the fourth and the fifth fingers. Panas[3] describes a case of paralysis excited by pressure from a sesamoid bone which lay in the internal lateral ligament of the elbow-joint. According to H. W. Page,[4] the ulnar nerve, when severed near the wrist, may be accompanied by *flexion of the little finger*.

It is a curious fact that in some instances of failure of the extensor muscles, following injury to the musculo-spiral nerve of the hand and wrist, the Interossei participate, although the ulnar nerve may not be involved.

In advanced paralysis of the extensor group from lead poisoning, the Extensor Carpi Ulnaris and the Opponens Pollicis may be involved.[5]

[1] Injuries of Nerves, 97.
[2] On Rest and Pain, 1877, 179.
[3] Acad. Med., 1877.
[4] Brit. Med. Journ., 1883.
[5] E. Remak, Archiv f. Psychiat. u. Nervenk., vi., 1875, 1.

The natives of India appear to be subject to a peculiar thickening of the ulnar nerve associated with caseous degeneration of the interior, and followed by wasting of the Flexor Carpi Ulnaris, the Adductor Pollicis, the Interossei, the intrinsic muscles of the fifth finger, and in part of the Opponens Pollicis, and Flexor Brevis Pollicis. Sensation is absent over the region of the dorsal and palmar surfaces of the fifth finger, and over the fifth metacarpal bone and adjacent surfaces as far as the styloid process of the ulna, as well as the fourth finger.

THE INTERNAL CUTANEOUS NERVE.

The Internal Cutaneous Nerve arises from the inner cord of the brachial plexus in common with the ulnar nerve. It is at first to the inner side of the axillary artery, and descends vertically along the inner surface of the arm, piercing the fascia at the middle third or at the junction of the lower with the middle third to become superficial at the same point that the basilic vein becomes deep seated. It accompanies this vein to the wrist. Here (sometimes before) it divides into two terminal branches, the *anterior* and *posterior*.

The *anterior branch* at the fold of the elbow divides into two branches, one of which passes in front and the other behind the median basilic vein. The more internal of these crosses the ulnar vein obliquely to reach the anterior surface of the forearm. A filament of this nerve anastomoses with the ulnar nerve. The external branch accompanies the median vein to the wrist, and sends a communicating branch to the external cutaneous nerve.

The *posterior branch* lies to the inner side of the basilic vein, and at the wrist lies behind the median basilic vein. It winds round the epitrochlea to gain the posterior surface of the forearm, where it divides into a number of branches. These for the most part pass vertically to the wrist, though one unites with the lesser internal cutaneous nerve, and another joins the dorsal cutaneous branch of the ulnar. While in the arm the internal cutaneous yields a single branch which passes down the posterior aspect of the arm to supply the skin as far as the elbow-joint.

Remarks.—The internal cutaneous nerve may be divided in venesection.

THE LESSER INTERNAL CUTANEOUS NERVE.

The Lesser Internal Cutaneous nerve (nerve of Wrisberg), the smallest branch of the brachial plexus, arises from the inner cord of the brachial plexus. It receives a branch of communication from the intercosto-humeral nerve, and passes downward to the

inner side of the brachial vessels. It crosses the united tendons of the Latissimus Dorsi and Teres Major muscles, and pierces the deep fascia above the middle of the arm. It now divides into an *internal* and an *external* branch, which are distributed to the integument of the inner and posterior aspects of the arm. According to Henle, a small branch winds around the tendon of the Latissimus Dorsi to the back of the shoulder.

Variations.—The lesser internal cutaneous is occasionally absent.

Remarks.—A. Seeligmüller[1] reports a case in which neuralgia was strictly limited to the branches of the lesser internal cutaneous nerve.

THE MEDIAN NERVE.

The Median Nerve (Plates LXXXV., fig. 2; LXXXVI.) is the motor nerve of the muscles flexing the wrist and the fingers, excepting the Flexor Carpi Ulnaris and the ulnar portion of the Flexor Profundus Digitorum. It also gives cutaneous branches to the radial half of the palm, and to the first, second, third, and part of the fourth fingers. The median nerve arises by two roots, one from the inner root of the brachial plexus in common with the ulnar nerve, the other from the outer root in common with the external cutaneous nerve. The two parts of origin converge acutely to form the trunk, embracing between them the axillary artery. The nerve lies first to the outer side of, and then upon, the brachial artery, in the depression between the Biceps and the Brachialis Anticus, but soon cross to the inner side of the artery. In the arm the nerve lies in front of the Brachialis Anticus to the inner border of the Coraco-Brachialis, to the median (inner) side of the brachial aponeurosis, and, in muscular individuals, the median border of the Biceps muscle. At the elbow the nerve passes beneath the aponeurotic slip of the Biceps muscle and between the two heads of the Pronator Radii Teres, piercing the Flexor Sublimis Digitorum between its humeral and ulnar heads, to gain admission to the space between the superficial and deep layers of the flexor muscles, along which it passes, running close to the Palmaris Longus muscle, to the lower third of the forearm. At the wrist it lies between the tendons of the Flexor Carpi Radialis and Palmaris Longus. Passing beneath the annular ligament it enters the palm and divides into its terminal branches.

At its lower fourth the nerve is accompanied by the artery of the median nerve. The synovial membranes beneath the annular ligament are prolonged upon the nerve in common with the tendons upon which it rests.

The branches of the Median Nerve are:—

- To the forearm
  - Articular,
  - Muscular,
  - Anterior Interosseous,
  - Palmar Cutaneous.
- To the hand
  - Muscular,
  - Digital.

The branches of the median nerve are confined to the forearm and hand, none being given off above the elbow, other than a small branch, often absent, forming a communication between the median and external cutaneous nerves.

Branches to the Forearm.—The Articular Branches. These are two in number, and supply the anterior surface of the capsule. One leaves the main trunk a little above the joint, and the second arises from the branch to the Pronator Quadratus. (Rüdinger.)

The Muscular Branches are numerous and confined to the flexor muscles of the forearm, excepting the Flexor Carpi Ulnaris and the ulnar half of the Flexor Profundus Digitorum, which are supplied by the ulnar nerve. The branch to the Pronator Radii Teres is distinct from the rest, and arises at a higher point. It occasionally yields branches which are distributed to the elbow-joint.

The Anterior Interosseous Nerve (deep branch of median nerve) arises from the main trunk behind the Pronator Radii Teres. It passes down the forearm, lying upon the interosseous membrane in company with the interosseous artery, between the Flexor Profundus Digitorum and the Flexor Longus Pollicis, supplying the last-mentioned muscle, together with the outer half of the first. It passes behind the Pronator Quadratus, and is lost within it. The nerve sends a branch between the laminæ of the interosse-

[1] Archiv f. Psychiatrie u. Nervenkrank., 1875, vi. 575.

EXPLANATION OF PLATE LXXXVI.

Fig. 1. A dissection exhibiting the nerves of the arm, as seen from in front.

Fig. 2. A dissection exhibiting the nerves of the forearm and the hand, seen from in front.

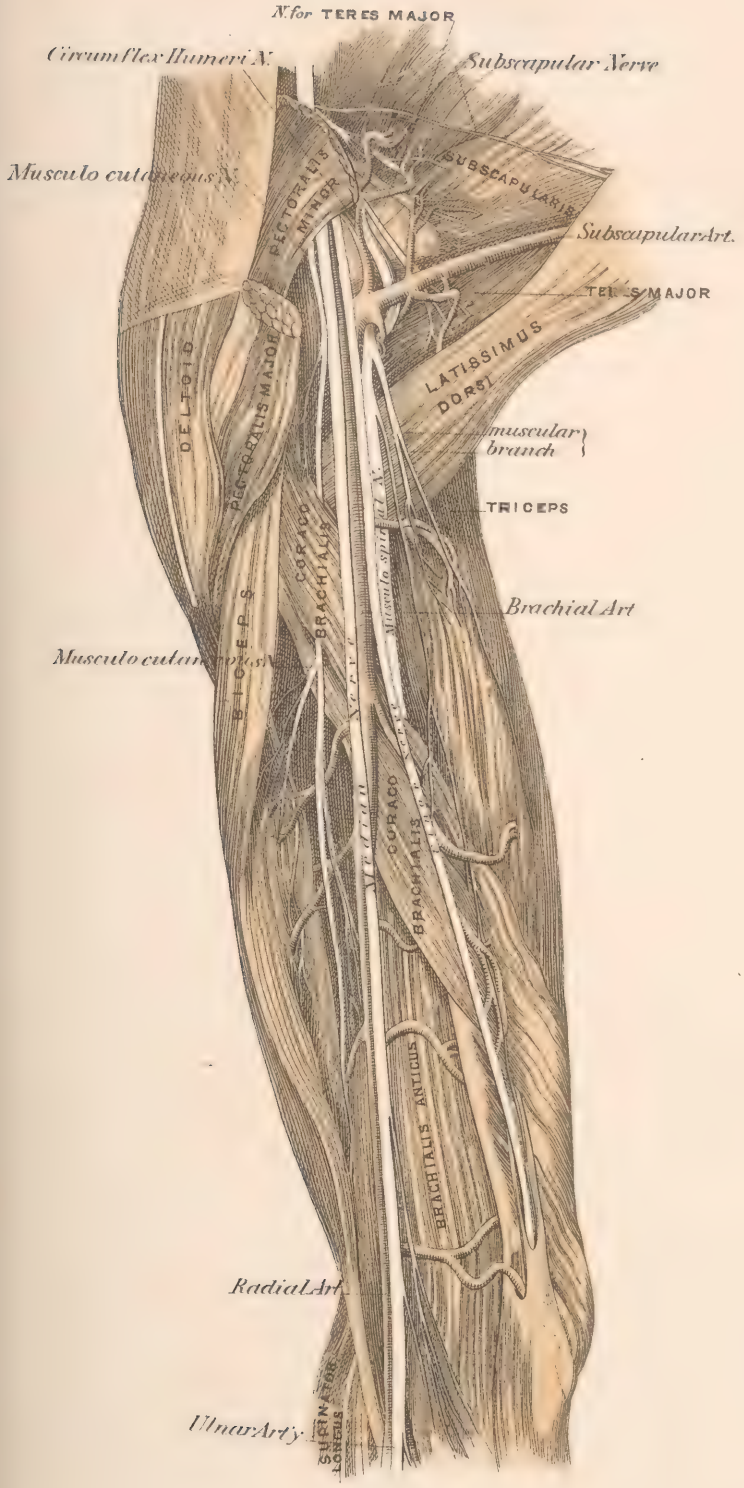


Fig. 1

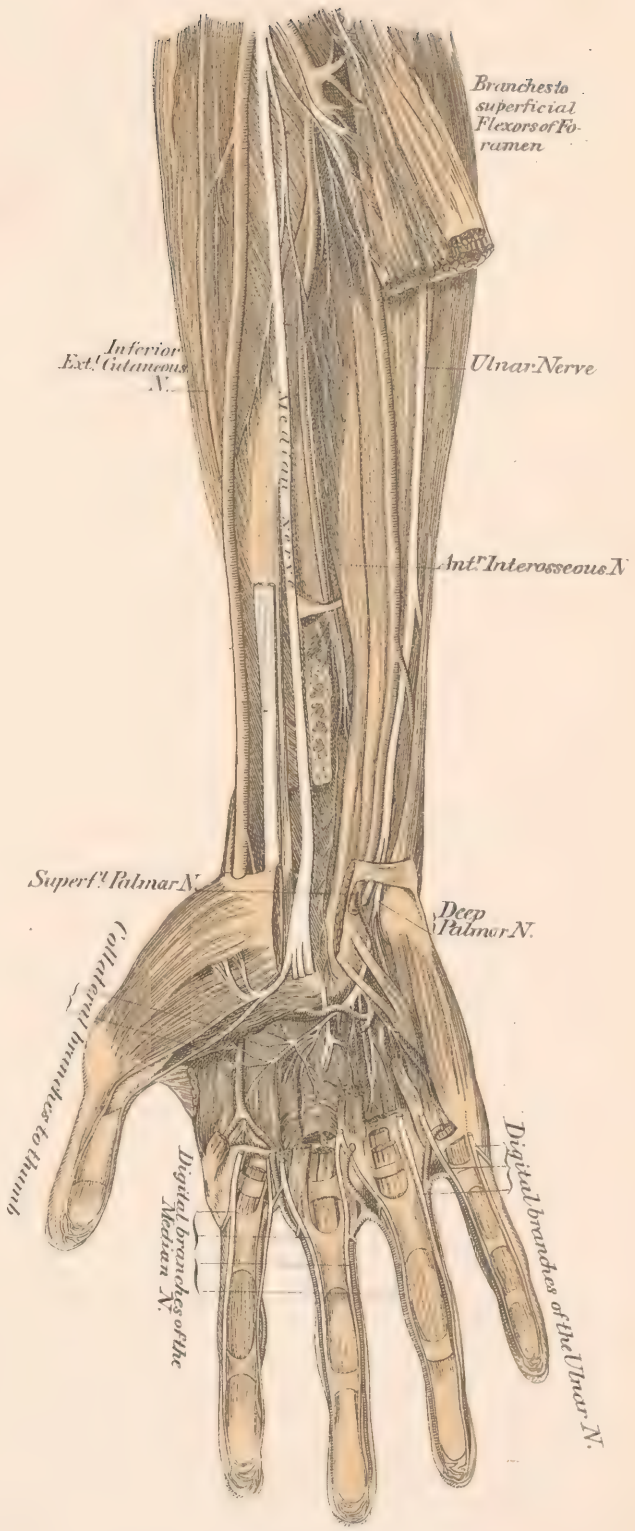


Fig. 2

T. Sinclair & Son, Lith.

ous membrane to supply the interior of the radius and ulna through the nutrient foramina. Some of its fibres reach the anterior aspect of the wrist-joint. This branch sometimes supplies the Flexor Longus Pollicis.

The Palmar Cutaneous Nerve (branch to Palmaris Longus) arises from the median nerve near the middle of the forearm; pierces the deep fascia to become superficial, passes downward along the tendon of the Palmaris Longus, in front of the annular ligament, to the hand; and divides into two branches, which are somewhat abruptly lost in the integument of the palm.

Branches to the Hand.—The median nerve divides immediately after passing the annular ligament into a muscular branch and branches to the digits. The Muscular branch curves outward and supplies the muscles of the ball of the thumb. The Digital branches are five in number, and are distributed as follows:—

The first passes along the tendon of the Flexor Longus Pollicis, obliquely outward to near the radial border of the thumb. The second, less oblique, crosses the Adductor Pollicis to be distributed to the ulnar border of the thumb. The third crosses the Adductor Pollicis to the radial border of the index finger, giving in addition a filament to the first Lumbrical muscle. The fourth lies upon the second interosseous space, and supplies the adjacent borders of the index and middle fingers, and sometimes the second Lumbrical muscle. The fifth passes in front of the third interosseous space, and supplies the adjacent borders of the middle and ring fingers. It sometimes gives a branch to the third Lumbrical.

The following is a summary of the distribution of the digital branches, according to Sappey: (1) They are placed in their entire course along the flexor tendons of the fingers. (2) At the base of the fingers one or two anastomotic branches are given off, which, directed obliquely downward and backward, embrace the dorsal branches arising from the radial and ulnar arteries. (3) They give a great number of ramifications to the skin of the palmar and lateral surfaces of the fingers. (4) Toward their ultimate distribution they divide into two main branches, one of which, the posterior or dorsal, ramifies to the subungual derm; while the other, the palmar, or anterior branch, anastomoses in the pulp of the finger with the corresponding filaments of the branch upon the opposite side of the finger. (5) Finally, filaments are found in association with the bodies known as Pacinian corpuscles.

While many of the muscular branches of the median nerve enter the muscles to which they belong by short trunks, one, the branch to the Pronator Quadratus, leaves the main trunk at a point far removed from the place of distribution. The nerve sends a filament to the brachial artery.

Variations.—The heads of the nerve may remain separate as far as the middle of the arm. A third head may arise from the ulnar nerve. The nerve may perforate the high origin of the Pronator Radii Teres muscle.

In a hundred arms dissected by Gruber, the median nerve crossed behind the brachial artery, instead of in front of it, in twenty instances. The outer head may pass behind the axillary artery. The nerve may run in company with the ulnar artery—an arrangement which is constant in the apes. It may compensate with the external cutaneous nerve. In like manner when the external cutaneous nerve ends in the region of the elbow, the median nerve may yield a branch which becomes superficial a little below the elbow, from which point it has a distribution similar to that of the terminal filaments of the normal external cutaneous nerve.

At its origin the nerve may fuse with the fibres of origin of the external cutaneous nerve for a considerable distance. The median nerve is sometimes found passing through the epicondyloid foramen; either alone, or, exceptionally, in company with the brachial artery, with a branch of this vessel, or with the ulnar artery. It may pierce the Flexor Sublimis Digitorum between its humeral and ulnar heads, as well as the Pronator Radii Teres.

Remarks.—The nerve has been repeatedly divided by wounds. Among the phenomena following such division are the following: loss of flexion of the fingers and hand; loss of pronation with retention of supination and flexure of the forearm; loss of sensibility over the radial half of the palm, and over the corresponding surfaces of the thumb, first and second fingers, and the radial half of the third. The limitation of this area is much less exact than that of the motor division of the nerve; for all the nerves contributing to the sensibility of the hand, viz., the superficial branch of the median, the ulnar, and the radial, either interchange fibres or effect frequent anastomoses. Richet[1] narrates an instance of section of the median nerve with perfect retention of sensibility of the palm.

Owing to the position of the median nerve in the loose connective tissue between the Flexor Sublimis Digitorum and the Flexor Profundus Digitorum, the median nerve may be contused and inflamed by the pressure of a cord drawn tightly round the wrist. Such injuries have been caused by a horse pulling upon a halter-strap which was wrapped round the wrist of the hostler, or by a person whose wrists were tied together behind the back falling violently forward.[2]

[1] Abstract, Lancet, 1867, ii. 681.

[2] Jas. Paget, Med. Times and Gaz., 1864.

Betrand[1] describes a sanguineous cyst in the upper part of the right median nerve.

A bursal tumor has been found by D. Hayes Agnew involving the median nerve at the elbow and the posterior interosseous trunk.

J. A. Ormerod,[2] narrates a case of a woman suffering from congenital syphilis, in whom the left median nerve was thickened in the arm, forming a fusiform tumor. Paresis of the flexors of the hand and the fingers, and impairment of pronation, were present. Flexion of the joints of the index finger was notably impaired, while the skin over the two distal joints of the index and middle fingers, and over the distal joint of the thumb, was without sensation.

The nerve may be pressed upon by callus extending forward from the anterior surface of the radius near the wrist.

J. Hilton[3] mentions a case of such pressure of callus on the median nerve from a fractured radius. The patient had ulceration of the skin of the first, second, and third fingers. The hand was purposely flexed, and put in such a position that all tension was taken off the median nerve. Under this treatment the ulceration disappeared; but as soon as the hand was allowed to be freely extended, the pressure of the callus caused a series of ulcers to appear as before.

W. Schnitzer[4] has inferred from clinical data that the dorsal surfaces of the second phalanx of the thumb, of the first phalanx of the second and third fingers, as well as often the lateral part of the dorsal aspect of the fourth finger, are supplied by the median nerve.

After wounds of the nerves, Sanders detected vesicles on the median part of the palmar surface of the third finger; on the dorsal surface of the second phalanx of the same finger; on the palmar surface of the first phalanx of the index finger; on the radial border of the second phalanx of the same finger; and in the palm in front of the ball of the thumb.

W. Krause[5] has carefully dissected the median nerve, and finds an elaborate plexiform arrangement of its fibres within the main trunk. It is every way likely that a similar disposition exists in the trunks of other nerves.

[1] These Faculté de Paris, 1837, No. 220.

[2] Trans. Path. Soc. Lond., 1881, 14.

[3] On Rest and Pain, 1877, 178.

[4] Übertraumat. Lähmungen der Armnerven, etc., Berlin, 1876. Abstract in Centralblatt für Med. Wissen., 1878, xvi. 190.

[5] Beiträge zur Neurologie der Oberen Extremität, Leipzic und Heidelberg, 1865, fig.

THE MUSCULO-SPIRAL NERVE.

The Musculo-Spiral Nerve (radial nerve, Plate LXXXVI.) supplies motor filaments to the extensors of the forearm, hand, and fingers; to the Supinator Longus, Extensor Carpi Radialis Longior, and often to the Brachialis Anticus; besides sending cutaneous branches to the front and back of the arm and forearm, and to the radial half of the dorsum of the hand. It is the largest branch of the brachial plexus, and arises from the posterior cord in common with the posterior circumflex nerve. The nerve passes downward, backward, and outward, overlying the subscapular artery, and in front of the tendons of the Latissimus Dorsi and Teres Major muscles, to reach the spiral groove upon the posterior surface of the humerus, along which it passes in company with the superior profunda artery and vein to the outer aspect of the arm at about the junction of the middle and the lower third. Piercing the intermuscular septum it becomes superficial within the groove between the Supinator Longus and Brachialis Anticus muscles, to reach the elbow in front of the epicondyle, where it divides into its terminal branches.

The Branches of the Musculo-Spiral Nerve include the following:—

Muscular.
Cutaneous.
Radial.
Posterior Interosseous.

Muscular Branches.—Above the elbow the musculo-spiral sends several branches to the Triceps as follows: (*a*) A branch to the long head. It divides into four or five diverging twigs as it enters the muscle. (*b*) A branch to the internal head. This nerve arises from the main trunk a little above the tendon of the Latissimus Dorsi, and, after sending an upper branch to the substance of the Triceps muscle, it passes toward the ulnar nerve and descends in its sheath[1] behind the internal intermuscular septum to the lower fourth of the arm. Leaving the ulnar nerve at this point, it supplies the lower part of the internal head of the Triceps muscle, and some fibres accompany the posterior ulnar recurrent artery to the elbow-joint. It follows that section of the ulnar nerve between the lower border of the Latissimus and the lower third of the arm, and may be followed by partial impairment of the function of the Triceps as well as by paralysis of the ulnar distribution. (*c*) A

[1] W. Krause, Arch. f. Anat., 1864, 349.

branch to the external head of the Triceps and to the Anconeus. This branch arises from the nerve as it lies in the groove.

Muscular branches (external) are also distributed to the upper portion of the Supinator Longus (a small branch commonly passing to the elbow-joint), and to the Extensor Carpi Radialis Longior muscle. A small branch is often sent to the Brachialis Anticus.

The Cutaneous Nerves.—A cutaneous (internal) nerve is distributed to the posterior and internal aspects of the arm as far as the elbow; a second (external) arising from the nerve on the outer border of the arm, is distributed to the back of the forearm. The nerve may be double, the upper division being directed to the fore part of the elbow along the cephalic vein. The lower branch pierces the deep fascia below the elbow and extends along the radial border of the posterior aspect of the forearm as far as the wrist.

The terminal branches of the musculo-spiral nerve are the posterior interosseous and the radial.

The *posterior interosseous nerve* (deep radial) is the larger of the two main divisions, and may be considered as the continuation of the musculo-spiral nerve. It perforates the Supinator Brevis, and in its substance winds spirally around the radius to gain the posterior aspect of the forearm. It here lies between the deep and superficial layers of the extensor muscles, and about the beginning of the lower third of the forearm reaches the interosseous membrane, and thence passes to the carpus. Its branches are as follows: Before its passage through the Supinator Brevis, twigs are given off to this muscle and to the Extensor Carpi Radialis Brevior, and not infrequently to the Extensor Carpi Radialis Longior. At its point of escape from the Supinator Brevis, it furnishes branches to the Extensor Carpi Ulnaris, the Extensor Communis Digitorum, the Extensor Minimi Digiti, and to the extensors of the thumb; a separate twig passing to the Extensor Indicis. Branches go to the periosteum of the radius and ulna, to the wrist-joint, and to the carpal and metacarpal joints.

The *radial nerve* (superficial radial), the cutaneous branch proper, arises at the level of the head of the radius, and passes downward between the Supinator Longus and Extensor Carpi Radialis Longior muscles, to the outer side of the radial artery, as far as the middle of the forearm, where it passes beneath, or to the radial side of, the tendon of the Supinator Longus, and lies to its outer side and upon the anterior surface of the Extensor Carpi Radialis Longior. It soon perforates the fascia, and, about one inch and a half above the wrist, it divides into an internal and an external branch.—The *external* branch (marginal branch) passes to the skin of the radial side of the thumb, and anastomoses with a filament of the external cutaneous nerve. The *internal* branch (dorsal manual branch), the larger of the two, crosses the tendons of the extensors of the thumb, and supplies the ulnar border of the thumb, and the radial border of the index finger. A third branch is distributed to the adjacent surfaces of the middle and index fingers, while a fourth joins the dorsal cutaneous branch of the ulnar nerve.

The musculo-spiral nerve supplies filaments to the radial artery.

Variations.—The branches of the radial nerve may compensate with the dorsal branch of the ulnar nerve in part. The nerve may yield the thoracico-dorsalis. The radial nerve may be double. The internal branch may compensate over the skin of the long head of the Triceps with the lesser internal cutaneous nerve and with the intercosto-humeral nerve.

Remarks.—The clinical application of the anatomy of the musculo-spiral nerve embraces the following subjects:—

(*a*) The effects of central lesions; (*b*) paralysis following division, or lead poisoning; (*c*) effects of pressure as the nerve passes behind the humerus.

(*a*) Paralysis of the extensors of the forearm and hand may be associated with lesions of the cerebral cortex. In like manner, degenerative changes in the anterior horn of the gray matter of the spinal cord may induce localized paralysis within the range of the nerve-distribution.[1]

(*b*) W. G. Savory[2] removed several inches of the musculo-spiral nerve for neuroma. While loss of power over the extensor muscles was noted, sensibility was retained over the region of the radial nerve distribution.

T. H. Holmes[3] reports a case in which the musculo-spiral nerve was divided a short distance above the elbow. Sensation over the region of the radial distribution was impaired, and extension of the wrist and of the fingers was lost. Supination and pronation with flexion of the elbow were retained.

Many of the points of clinical interest in connection with the musculo spiral nerve may be explained on the basis of the greater weakness of the extensor muscles as compared with the flexors and the various

[1] Grasset, Maladies du Système Nerveux, 997.
[2] Lancet, 1868, ii. 142.
[3] Lancet, 1883, i. 1084.

degrees of resisting power of the extensors. The fact that in wounds of the brachial plexus the extensors are more liable to become paralyzed than the flexors, is in harmony with this proposition. It will be remembered that the musculo-spiral nerve supplies all the extensors of the forearm, wrist, and fingers, excepting the Interossei, and one flexor of the forearm, namely, the Supinator Longus. The branch to the Supinator Longus muscle is usually exempt in lead palsy. In the same affection it has been noted that the Extensor Indicis and the Extensor Minimi Digiti resist the effects of the disease a longer time than does the Extensor Communis Digitorum. The Triceps resists the effects of muscular atrophy a longer time than does any muscle supplied by the musculo-spiral nerve.

Erichsen[1] reports a case of paralysis of the extensors of the hand following fracture of the humerus at its middle portion, in which the Supinator Longus did not participate. S. Weir Mitchell[2] has reported a case of contusion from a fragment of a shell in which the extensors of the wrist, thumb, and fingers were completely paralyzed, while the action of the Supinator Longus was but slightly impaired.

As opposed to these statements the last-quoted writer[3] details an instance of paralysis of the median and ulnar nerves in which the Supinator Longus suffered impairment of power, the remaining portions of the musculo-spiral distribution remaining in a normal condition.

It must be borne in mind that some of the effects of injury to the nerve may be reflex in character, and that a knowledge of the distribution of the nerve may be of little real value in interpreting the symptoms. Thus, in a case recorded by A. Denmark,[4] the hand was flexed, and the forearm flexed and supinated, and burning pain was experienced at the tips of all the fingers except the fifth. Here, while the Supinator Longus may be assumed to be excited, explaining the flexion of the forearm and the supination, the flexion of the hand remains unaccounted for, except by the theory of reflex action.

In addition to the fact that the extensor group of muscles is the weaker, it is rational to conclude, since Onimus[5] found that the radial nerve is the first to lose its excitability after death, that the musculo-spiral nerve, in its sensory as well as its motor branches, is of low vital power.

The muscles of the ball of the thumb and some of the Interossei muscles may be paralyzed in lead palsy, although not supplied by the musculo-spiral nerve.[1]

(*c*) The nerve is specially liable to compression as it winds round the humerus from behind. The trunk is readily affected by external pressure, as in the act of lying prone with the superior extremity thrust beneath the body; it may be imbedded in callus; it may be involved in rheumatic or inflammatory processes affecting the periosteum lining the groove. In all three conditions it will be seen that the Triceps muscle need not be involved, since the branches of supply arise from the nerve before it winds round the bone.

THE EXTERNAL CUTANEOUS NERVE.

The External Cutaneous nerve (musculo-cutaneous nerve, perforans Casserii) arises from the outer cord of the brachial plexus, together with the outer head of the median nerve (Plate LXXXVI., fig. 1). The nerve passes downward upon the tendon of the Subscapularis, perforates the Coraco-Brachialis obliquely, and is received within the groove between the Supinator Longus and the Brachialis Anticus, along which it descends to the elbow-joint. It pierces the brachial fascia between the Supinator Longus and the tendon of the Biceps, and divides into the terminal branches, the anterior and the posterior, which are cutaneous. Near the wrist it lies along the line of the tendon of the Supinator Longus, outside of the deep fascia.

The branches of the external cutaneous nerve embrace the following: A small twig from near the origin supplies the walls of the brachial artery, and enters the nutrient canal of the humerus. A branch goes to the Coraco-Brachialis muscle, another to the Biceps, and a small branch to the Brachialis Anticus, and to the elbow-joint. The terminal cutaneous branches.—Several minute cutaneous branches may be distributed to the skin about the elbow-joint.

The terminal branches are placed one in front of the other, behind the median cephalic vein. The *anterior* branch (internal branch) descends vertically between the radial and median veins, along the radial border of the forearm to the wrist, and to the skin over the ball of the thumb. A conspicuous branch accompanies the median cephalic vein, and generally at the lower part of the forearm is in company with the radial artery. It anastomoses with the internal cutaneous, and, a little above the wrist, with the radial nerve. The *posterior* branch (external branch) is at first in front of the outer border of the forearm, but soon becomes posterior. It is lost in the integument of the back of the arm.

[1] Lancet, 1871, ii. 1.
[2] Injuries to Nerves, 189.
[3] Loc. cit., 211.
[4] Med. Chir. Trans., 1813, iv. 48.
[5] Journ. de l'Anat. et de la Physiol., 1880, No. 6.

[1] E. Remak, Archiv f. Psychiatrie u. Nervenkrank., 1875, vi. 1.

Variations.—The external cutaneous nerve may be absent, when the nerve for the Coraco-Brachialis may arise independently from the brachial plexus, and the remaining branches from the median. The nerve may supply the Coraco-Brachialis, Biceps, and Brachialis Anticus muscles, the cutaneous branches arising from the median. It may supply the Supinator Brevis. In nearly one-half of the cases the nerve receives in the upper arm a branch from the median nerve.[1] The nerve may fail to pass through the Coraco-Brachialis, or it may, while pursuing the normal course in this regard, pass through the Brachialis Anticus or the short head of the Biceps. The nerve often lies to the outer side of the brachial artery. The muscular and cutaneous portions may arise separately from the plexus.

Remarks.—Profound reflexes, affecting the entire group of muscles of the superior extremity, may be excited by division or injury of the external cutaneous nerve, as in venesection. In extreme instances of lead palsy the muscles to which this nerve is distributed may be involved.[2] The nerve may be involved in common with the circumflex in an obscure form of paralysis.

THE DORSAL NERVES.

The Dorsal Nerves are those arising from the spinal cord in the dorsal region. They form the nerves of the walls of the trunk. They aid, besides, in the formation of the brachial plexus, yield cutaneous filaments to the axilla, to the inner and back part of the arms, and to the costal portions of the Diaphragm.

The dorsal nerves are twelve in number, and, like other spinal nerves, are formed by the union of two roots, an anterior and a posterior. The first nerve is the largest, and from the first to the ninth the nerves gradually decrease in size; but from the ninth to the twelfth they again increase gradually. The intervals between the points of origin of the dorsal nerves are greater than those between the other spinal nerves, the upper ones, viz., from the first to the sixth, being further apart than those from the sixth to the twelfth.

The nerves escape from the intervertebral foramina, and each divides into two branches, an anterior larger and a posterior smaller branch.

Close to the foramina short communicating branches are given off to the sympathetic system.

INTERCOSTAL NERVES.

The *anterior branches* form the *intercostal nerves* (Plate XCI.), twelve in number on each side, and these may be divided into two sets, from the difference they present in their distribution. The first six are distributed to the parietes of the chest, and may be called the upper or thoracic intercostal nerves; the remaining nerves are distributed to the parietes of the chest and abdomen, and may be called the lower or abdominal intercostal nerves.

The upper or *thoracic intercostal nerves.* Each nerve passes forward to reach an intercostal space, along which it passes nearly as far as the sternum, below, but on the same perpendicular plane with the corresponding intercostal artery and vein. At first the nerve lies on the External Intercostal muscle, where it is covered by the endothoracic fascia and the pleura. The nerve soon passes between the Internal Intercostal and External Intercostal muscles, to which it sends filaments, and emerges beyond the External Intercostal, from which point to the sternum it lies beneath the pleura. In its course it crosses the internal mammary artery and the Triangularis Sterni muscle, and pierces the Internal Intercostal muscle and the sternal origin of the Pectoralis Major, after which it assumes the name of the *anterior cutaneous* nerve, and is distributed to the skin of the pectoral region.

The lower or abdominal intercostal nerves. In the abdomen the anterior branches pass between the Internal Oblique and the Transversalis muscles, and pierce the outer edge of the sheath of the Rectus muscle. After supplying this muscle they escape through the sheath anteriorly in company with the perforating arteries, and, together with these vessels, supply the skin of the abdomen near the linea alba. Small twigs arising from the abdominal intercostal nerves supply the Diaphragm at its costal attachments (Luschka).

The upper or thoracic nerves are united by small branches, one between each pair, extending over the costal cartilages.

An important branch from each intercostal nerve, which is given off midway between the vertebral column and the sternum, has received the name of the *lateral cutaneous* nerve. This nerve pierces the muscles of the side of the trunk, and divides into an anterior and a posterior branch, which are distributed to superficial parts.

The lateral cutaneous nerves, from the first to the seventh, pass through the External Intercostals and the digitations of the Serratus Magnus muscle in a line behind the pectoral border of the axilla. The *anterior branches* go forward over the outer border of the Pectoralis Major muscle, and supply twigs to the mammary gland, to the upper digitations of the

[1] C. Gegenbaur, Jenaische Zeitschr. für Medicin., 1866, 258. See, also, L. Testut, Journ. de l'Anat. et de Phys., 1883, xix. 97.

[2] E. Remak, Archiv f. Psychiatrie u. Nervenkrank., 1875, vi. 1.

External Oblique, and to the skin of adjacent parts. The *posterior branches* pass backward, and supply the median border of the Latissimus Dorsi muscle and the integument over the scapula.

The *posterior division* of each dorsal nerve, the smaller of the two, lies between the transverse processes. Reaching the neck of the corresponding rib, it enters the region of the back between the transverse processes of the dorsal vertebræ, and is distributed to the muscles and skin of the back. The nerve soon divides into two branches, an internal or median and an external or lateral branch.

From the first six thoracic nerves, cutaneous branches reach the surface by penetrating the Serratus Posticus Superior, Rhomboideus, Trapezius, and Latissimus Dorsi muscles.

The *median* branches of the six lower nerves pass through the Serratus Posticus Inferior and Latissimus Dorsi muscles. The *lateral* (external) branches extend through the muscular interspace between the Sacro-Lumbalis and Longissimus Dorsi to be distributed to these muscles and the Levatores Costarum. The last six finally pierce the vertebral aponeurosis and the Serratus Posticus Inferior and Latissimus Dorsi muscles, and are lost in the skin of the back, branches being given to the Latissimus Dorsi and Rhomboideus muscles as well as to the Trapezius, and to the skin over this muscle. They also supply the skin over the Infra-Spinatus region.

The first, second, and twelfth dorsal nerves present the following peculiarities:—

The first nerve has a very large anterior division which ascends on the first rib to join the brachial plexus. The anterior division of this nerve is not, therefore, the first intercostal; the latter is a separate branch, and arises from the anterior division, in the same way that the lateral cutaneous branches arise from the other intercostal nerves. The lateral cutaneous nerve is absent.

The second nerve possesses a lateral cutaneous branch, called the *intercosto-humeral nerve*, which sends a branch to the axilla and inner side of the arm, where it is joined by a branch from the lesser internal cutaneous nerve.

The twelfth dorsal nerve lies below the last rib in front of the Quadratus Lumborum, perforates the aponeurosis of the Transversalis Abdominalis muscle, and thence passes forward between the last-named muscle and the Internal Oblique. As the first dorsal nerve has pronounced relations with the cervical nerves, so the last is connected with the lumbar nerves. It commonly joins the ilio-hypogastric nerve; and a branch passing from it to the Quadratus Lumborum is called the *dorso-lumbar* nerve. The lateral cutaneous branch descends almost vertically over the crest of the ilium to supply the skin about the region of the hip. It is without an anterior or a posterior branch.

To the above branches of the dorsal nerves may be added the *recurrent nerves*, which enter the vertebral canal through the inter-vertebral foramina, supplying the walls of the intra-spinal veins.

The orifices of exit of the dorsal nerves from the vertebral canal are surrounded by a venous plexus (*circellus foraminis inter-vertebralis*) belonging to the intra-spinal veins.

Variations.—The intercostal nerves may divide into two parallel branches, which, however, soon again unite. The first, second, and third intercostal nerves may give branches to the skin of the upper arm. The intercostals, commonly the second and fourth, may unite by small branches which cross obliquely the hinder portion of the ribs. The twelfth intercostal may unite with a branch of the first lumbar nerve, and may send a branch through the external abdominal muscles to supply the skin at the lower portion of the abdomen. The third intercostal may give off an additional intercosto-humeral nerve.

Variations.—J. B. Perrin[1] found the first dorsal nerve passing obliquely downward and forward, perforating the Scalenus Anticus near the first rib, thence passing directly outward to join with the inner branch of the anterior division of the eighth cervical nerve, and lying in close relation to the inner and lower side of the third part of the subclavian artery, between this vessel and the subclavian vein.

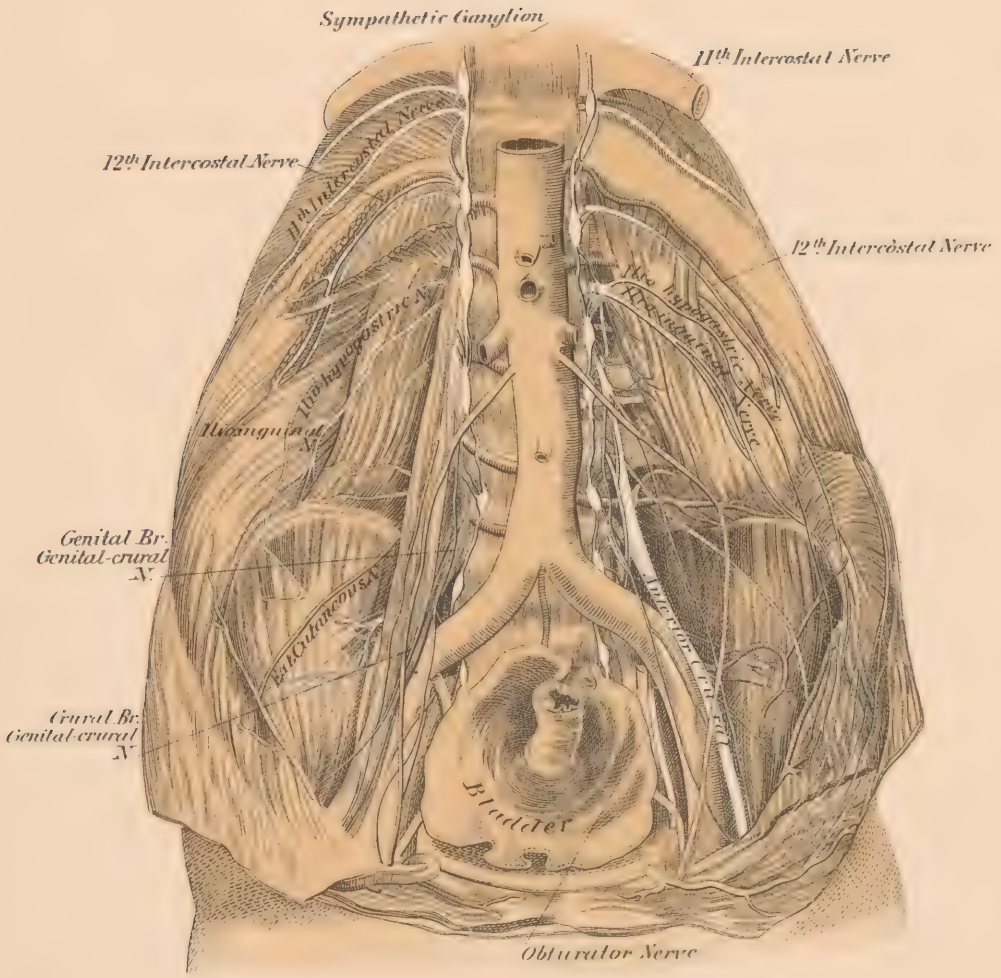
A connecting twig is ordinarily seen to pass between the anterior divisions of the first and second dorsal nerves. In thirty-seven dissections made by D. J. Cunningham,[2] it was absent in ten only. "It springs from the anterior primary division of the second dorsal nerve close to its origin; it passes up over the neck of the second rib, and usually ends by joining both the brachial and the intercostal divisions of the first dorsal nerve."

[1] Br. and For. Med.-Chir. Rev., 1876, lvii. 194.

[2] Journ. Anat. and Phys., April, 1877, 539.

EXPLANATION OF PLATE LXXXVII.

A dissection exhibiting the sympathetic ganglia of the lumbar region and the branches of the lumbar plexus.



T. Sinclair & Son Lith.

Remarks.—In congested conditions of the intercostal veins, the nerve-trunks may be compressed; the degree of such compression is proportionate to the amount of congestion; and this in turn is greater on the left than on the right side of the body, for the reason that the left intercostal veins pass behind the descending aorta and thoracic duct on their way to the right side of the vertebral column. It is thought that they may be compressed by these structures, and that the escape of blood from the intervertebral veins is thus retarded. Luschka attributes to this cause the frequent occurrence of intercostal neuralgia of the left side of the chest. Since, however, the neuralgic pains in this region are frequently connected with a distended colon and a high degree of elevation of the Diaphragm, the etiology of the "infra-mammary" pain, at least, in the left side can be best explained by the condition of the abdominal viscera. It is nevertheless well to remember the mechanism described by Luschka, particularly in those examples of peripheral costal neuralgias which are associated with disease of the spinal cord or vertebræ. A valuable point in the differential diagnosis of pain, when referred to the median line of the abdomen and chest, can sometimes be made by remembering the method of escape of the dorsal nerves. A doubt may arise respecting the compression of the nerves by an embracing venous plexus, but none to the effect that effusions within the vertebral canal, or pressure from inflammatory products, or deformity attending caries of the vertebræ, may not so compress them. One of the results of this squeezing is to create a neuralgic pain which is referred to the skin of the front of the trunk.

The pains of pleurisy may be referred with certainty to the compression of the main trunks of the intercostal nerves by the products of inflammation; either as the nerves lie unprotected beneath the pleura and endo-thoracic fascia before they pass between the Intercostal muscles, or as they escape anteriorly from these muscles. Pressure upon exposed twigs, such as those uniting some of the upper nerves at the costal cartilages, may also cause them. The last dorsal nerve, together with the ilio-hypogastric nerves, is liable to division in the operation of lumbar colotomy.

THE LUMBAR NERVES.

The Lumbar Nerves are five in number, and present for examination a posterior and an anterior set of branches.

The *posterior branches* decrease in size from above downward. They pass between the transverse processes of the vertebræ, and divide into *external* and *internal* branches. The former supply the Erector Spinæ and Interosseous muscles, the latter the Multifidi Spinæ and the Interspinales. Cutaneous branches of the external division pierce the Sacro-Lumbalis and the Latissimus Dorsi, and supply the skin of the loin and buttock as far as the region of the trochanter.

The *anterior branches* increase in size from above downward, so that the lower are broader and stouter than the upper. The first three nerves closely resemble the intercostal nerves in their general disposition.

THE LUMBAR PLEXUS.

The anterior branches are intimately united to constitute the *lumbar plexus* (Plate LXXXVII. and Plate XCII.), which is arranged as follows:—

The *first lumbar nerve*[1] gives off the ilio-hypogastric and ilio-lumbar nerves, a twig to the Quadratus Lumborum, and a stout communicating branch to the second lumbar nerve. The *second lumbar nerve* gives off a root of the genito-crural, the remaining root springing from the communicating branch from the first nerve. The second nerve sends a stout communicating branch to the third, which yields two twigs to the Psoas muscle and gives origin to the external cutaneous nerve. The *third* and *fourth lumbar nerves*, together with the communicating branch of the second lumbar nerve, form an intricate portion of the plexus, which yields the external cutaneous, the roots of the anterior crural, and the roots of the obturator nerve. Each of these nerves arises from three roots, one from the communicating branch between the second and third, one from the communicating branch between the third and fourth, and one from the fourth lumbar nerve. A portion of the fourth lumbar nerve unites with the fifth to form the *lumbo-sacral* nerve.

The following arrangement, since it differs in some measure from the one selected for the text, is given in a separate section. It is essentially the method of the French writers.

The *first lumbar nerve* divides into three branches. Two of these form the ilio-hypogastric and ilio-inguinal nerves. The third forms the communicating branch with the second lumbar. The communicating branch is directed vertically downward, and reaches the second nerve soon after its exit from the intervertebral foramen.

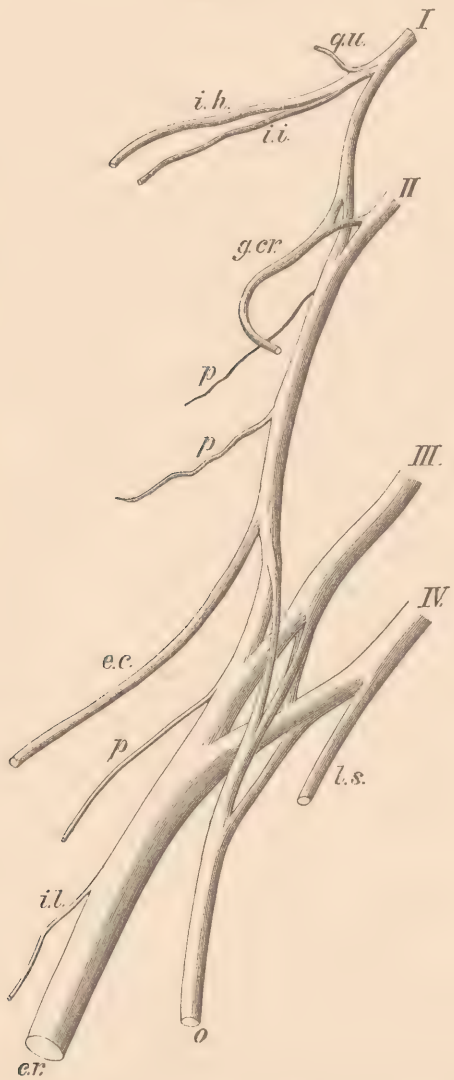
The *second lumbar nerve*, larger than the preceding, gives off the genito-crural and external cutaneous nerves. It furnishes a branch to the Psoas muscle, and anastomoses with the third lumbar nerve. The latter branch is directed a little outward, and divides into two portions, the inner of

[1] Schwalbe, Neurologie, 947.

which passes over the third lumbar nerve to the loop between the third and fourth, while the outer is united to the third lumbar nerve.

The *third lumbar nerve* is, in turn, larger than the second. It is directed downward and outward, being joined by a branch from the second. Its branches are irregular, but are usually arranged so that one goes to the crural nerve, the other to the obturator nerve.

Fig. 124.



A diagrammatic drawing of the lumbar plexus. *I*, first lumbar nerve; *II*, second lumbar nerve; *III*, third lumbar nerve; *IV*, fourth lumbar nerve; *qu*, nerve for Quadratus Lumborum; *i h*, hypogastric nerve; *i i*, ilio-lumbar nerve; *g c r*, genito-crural nerve; *p p p*, branches to the Psoas muscle; *e c*, external cutaneous nerve; *i l*, ilio-lumbar nerve; *o*, obturator nerve; *c r*, anterior crural; *l s*, branch to lumbo-sacral nerve.

The *fourth lumbar nerve*, still larger than the third, presents three branches: an external, which joins the external branch of the third to constitute one head of the crural nerve; a middle, which unites with the internal bifurcation of the same nerve to form one root of the obturator nerve; and an internal vertical loop which joins the fifth. It may also furnish a part of the origin of the accessory obturator nerve.

The *fifth lumbar*, sometimes larger than the fourth, receives the internal branch of that nerve, and with it forms a large trunk which constitutes the lumbo-sacral nerve.

The lumbar plexus is of a triangular shape, the base being downward. It lies in front of the bodies and transverse processes of the lumbar vertebræ, within the substance of the Psoas Magnus muscle. The branch of communication between the lumbar plexus and the dorsal nerves is known as the *dorso-lumbar* nerve; that between the lumbar and the sacral plexus as the *lumbo-sacral nerve*. The lumbar plexus unites with the sympathetic system of nerves by delicate branches which accompany the lumbar arteries.

The branches of the lumbar plexus form two groups, one pertaining chiefly to the wall of the abdomen and external genitals, and the other to the lower extremity. In the first group, which is shorter and more superficial than the other, are included the ilio-hypogastric, ilio-inguinal, genito-crural, and external cutaneous nerves; in the second, the anterior crural, obturator, and accessory obturator nerves.

The experimental researches of D. Ferrier and J. B. Yeo[1] on the monkey yield the following results:—

Stimulation of the *fifth lumbar nerve* is followed by outward rotation of the thigh, flexion and inward rotation of the leg, plantar flexion of the foot, and flexion of the distal phalanges.

Stimulation of the *fourth lumbar nerve* causes extension of the thigh, extension of the leg, and pointing of the great toe.

Stimulation of the *third lumbar nerve* causes flexion of the thigh, and extension of the leg.[2]

Variations.—L. P. Davidson[3] found the ganglia double for the first, second, third, and fourth lumbar nerves of the left side. The third and the fourth were double on the right side. In some instances the ganglia were separate, while in others they were united by commissures. In another subject the ganglia of the third, fourth, and fifth nerves of the left side, and of the second, third, fourth, and fifth nerves of the right side, were double. The cutaneous branches of the lumbar nerves may not enter into the construction of the plexus.

Remarks.—According to A. Ure,[4] the ilio-lumbar nerve may be torn across in contusions such as may accompany fracture of the pelvis. The branches of the plexus may be compressed by the lumbar veins, by impacted feces in the colon, and by the products of inflammation in typhlitis and psoas abscess. Many

[1] Proc. Royal Soc., No. 212, 12; also Brain, iv., 1881, 224.
[2] See, also, Ch. Féré, Archives de Neurologie, 1883, v. 332.
[3] Lancet, August, 1880. [4] Ibid., 1857, i. 315.

kinds of radiating neuralgic pains of the lower extremity find their explanation in these and analogous causes.

THE ILIO-HYPOGASTRIC NERVE.

The Ilio-Hypogastric Nerve (Plate LXXXVII.) runs parallel to the last intercostal nerve, with which it sometimes anastomoses. It arises from the first lumbar nerve, generally pierces the Psoas Magnus muscle, passes almost horizontally outward across the Quadratus Lumborum, pierces the tendon of the Transversalis muscle at its junction with the muscular portion, and passes down between the Transversalis and Obliquus Internus close to the middle of the crest of the ilium, where it divides into two branches, an external and an internal. The *external branch* (gluteal branch, iliac branch) pierces the Internal Oblique and the tendon of the External Oblique, to gain the subcutaneous tissue over the buttock. The *internal branch* (pubic branch, hypogastric branch) passes forward beneath the tendon of the External Oblique above Poupart's ligament to the sheath of the Rectus, which it pierces to reach the skin of the hypogastric region, where its branches are distributed.

Variations.—The ilio-hypogastric nerve is subject to great variations in its ultimate distribution. Frequently a branch passes along the inguinal canal to the external abdominal ring, where it escapes to supply the skin of the hypogastric region. It anastomoses with the anterior root of the last intercostal nerve, and with the second branch of the lumbar plexus.

The external branch is homologous with the lateral cutaneous branch of an intercostal nerve. As such it compensates with the lateral cutaneous branch of the last lumbar nerve. It frequently unites with the ilio-hypogastric nerve between the Transversalis and Internal Oblique muscles.

THE ILIO-INGUINAL NERVE.

The Ilio-Inguinal Nerve (Plate LXXXVII.) arises from the first lumbar nerve in common with the preceding. It passes outward and downward through the Psoas Magnus a little below the hypogastric branch, and appears at the outer border of the Psoas; then it crosses the Quadratus Lumborum and the iliac fossa to pierce the Transversalis muscle a little above Poupart's ligament, thus gaining entrance to the inguinal canal, along which it passes to the external abdominal ring, where it divides into branches which supply the skin of the pubis, and the skin of the penis and scrotum in the male, and of the labia majora in the female. Before entering the inguinal canal a small cutaneous branch supplies the skin over the Tensor Vaginæ Femoris and the origin of the Sartorius muscle, and the fibres of the Obliquus Internus near the anterior superior spinous process.

Variations.—A branch may pass to the anterior surface of the spermatic cord. A small twig may supply the Rectus Abdominalis. The nerves may not be united near their origin with the ilio-hypogastric. According to Bankert, Smith, and Phillips,[1] the first lumbar nerve gives off three branches, the iliac, ilio-hypogastric, and ilio-inguinal.

THE GENITO-CRURAL NERVE.

The Genito-Crural Nerve (Plate LXXXVII.) arises from the second lumbar nerve, or from the branch of communication between it and the first. It passes almost vertically downward through the substance of the Psoas muscle, gradually reaching its median border at the height of the third or fourth lumbar nerve. It thence passes downward to the region of Poupart's ligament, near which it divides into two branches, an internal and an external.

The internal branch (genital branch, external spermatic branch) lies at first on the external iliac artery, then enters the inguinal canal by piercing its hinder wall, passes along below the spermatic cord to the external abdominal ring, and thence to the scrotum, where it supplies the Cremaster muscle and the dartos. In the female it supplies the labium majus.

The external femoral branch (lumbo-inguinal branch) escapes through the crural arch to the inner side of the anterior crural nerve, is distributed to the skin of the inner side of the thigh, and anastomoses with the middle cutaneous branch of the anterior crural nerve. A small filament often descends a short distance over the femoral artery. It may also give branches to the lower border of the Obliquus Internus and Transversalis muscles.

THE EXTERNAL CUTANEOUS NERVE.

The External Cutaneous Nerve (lateral cutaneous nerve) arises from the second lumbar nerve or from the loop of communication between it and the third (Plate LXXXIX., fig. 1). It passes outward and downward through the substance of the Psoas, and afterward on the Iliacus muscle, to a point just below the anterior superior spinous process of the ilium, where it passes beneath Poupart's ligament and divides into two branches, a posterior or gluteal and an anterior or

[1] St. Thomas's Hosp. Rep., 1874, v. 285.

femoral. The *posterior* generally yields an upper and a lower branch which pass backward and downward over the buttock and upper part of the thigh. The *anterior* branch descends the thigh under cover of the fascia lata to about four inches below Poupart's ligament, where it pierces the fascia lata, and is distributed in the subcutaneous fat nearly as far as the knee. In some cases it may reach the knee and anastomose with the internal saphenous nerve. This branch may be duplicated, when it freely anastomoses with the cutaneous branch of the anterior crural. The branches of the main portion are given off chiefly from its outer side.

Variations.—The nerve may arise from the third and fourth lumbar nerves directly or through the medium of the roots of the anterior crural nerve. It may lie over the Iliacus in two or more divisions, one passing under Poupart's ligament internal to the notch below the anterior superior spinous process of the ilium, the other passing over the ligament.[1]

THE OBTURATOR NERVE.

The Obturator Nerve (Plate LXXXIX., fig. 1) arises from the third and fourth nerves of the lumbar plexus (*vide* Variations). It descends, concealed at first within the inner margin of the Psoas muscle, to the brim of the true pelvis, a short distance below which it extends forward above the obturator artery and nerve to the obturator membrane. It here pierces the obturator foramen, and immediately divides into two sets of branches, a deep and a superficial.

The *deep* or *posterior* portion, which constitutes the continuation of the main nerve, passes behind the Adductor Brevis, and is distributed for the most part within the Adductor Magnus, the fibres of which it penetrates along the posterior margin, although the Obturator Externus and Adductor Brevis may also receive branches. The most remarkable branch of the deep group is the articular; this pierces the Adductor Magnus muscle to gain the upper part of the popliteal space, along which it descends to reach the back of the knee, where it pierces the posterior ligament, and is lost within the joint. It supplies in its descent a network of branches to the popliteal artery.

The *superficial* or *anterior* division passes in front of the Adductor Brevis, supplies branches to the Adductor Longus, Adductor Brevis, Gracilis, and rarely to the Pectineus. It also supplies an articular branch to the hip-joint, and terminal twigs to the femoral artery. A cutaneous branch often arises from the superficial division of the obturator and descends to the knee, where it perforates the fascia to join the branches of the internal saphenous nerve there situated, and continues downward some distance below the joint. This branch also anastomoses with the internal cutaneous branch of the anterior crural nerve.

The Accessory Obturator is a small and inconstant nerve, which, when present, arises from the upper portion of the obturator nerve, and which, instead of escaping at the obturator foramen, passes over the horizontal ramus of the pubis to enter the region of the thigh beneath the Pectineus muscle. It anastomoses with the superficial branch to supply the Pectineus, the Adductor Brevis, and the hip-joint.

Variations.—The obturator nerve may arise from the second, third, and fourth lumbar nerves. The accessory obturator may anastomose with the obturator and the internal cutaneous nerves.

Remarks.—The intra-pelvic portion of the obturator nerve may be compressed by the fœtal head, by cancerous growths of the rectum, or by feces.[1] Pressure on the branch to the hip-joint may excite reflex pains, which are referred to the knee-joint and the back part of the leg, through the cutaneous branch and its anastomoses.[2]

THE ANTERIOR CRURAL NERVE.

The Anterior Crural Nerve (Plate LXXXIX., fig. 1), the largest branch of the lumbar plexus, arises by roots received from the third and fourth nerves, particularly the last, and from the loop between the second and third. It passes almost vertically downward, at first within the substance of the Psoas muscle, but afterward in the groove between it and the Iliacus Internus, and escapes from the pelvis beneath Poupart's ligament to the outer side of the femoral vein. It almost immediately divides into two main portions, constituting a superficial and a deep set of branches. Before division the following nerves arise from it: within the pelvis several transverse branches leave its outer side, and are distributed to the Iliacus muscle. Just below Poupart's ligament, several cutaneous branches pierce the fascia lata, and supply the upper part of the femoral sheath and the skin below the fold of the groin. A branch to the Pectineus muscle is also given off here.

[1] Bankert, Smith, and Phillips, St. Thomas's Hosp. Reports, 1874, v. 285.

[1] J. Hilton, On Rest and Pain, 199. [2] Ibid., 198.

The branches of the anterior crural nerve are as follows:—

Superficial division	Internal Cutaneous nerve.
	Middle Cutaneous nerve.
Deep division	Muscular Branches.
	Internal Saphenous nerve.

The *superficial* group of nerves is the most internal, and sends branches to the skin and the Sartorius muscle.

The Internal Cutaneous Nerve (Plate LXXXVIII., fig. 2), slender and often double, passes down in the sheath of the femoral vessels, penetrates the fascia at about the middle of the thigh, and unites generally with the anterior branch of the obturator nerve. It crosses obliquely the upper part of the femoral artery, and divides into two branches, the anterior and the posterior. The *anterior* branch descends near the vein to the lower third of the thigh, where it perforates the fascia and turns forward to be distributed above the patella and to its outer side. Above the joint it communicates with a branch of the internal saphenous nerve, pierces the deep fascia, and is lost along the inner side of the thigh. The *posterior* branch descends along the inner border of the Sartorius, perforates the fascia at the inner side of the knee, and communicates with a small branch of the internal saphenous nerve. It supplies the inner side of the knee, and joins the cutaneous branch of the obturator nerve. A deep branch enters the femoral sheath, and passes along in front of the femoral vessels.

The Middle Cutaneous Nerve (Plate LXXXVIII., fig. 2) pierces the Sartorius at its upper fourth, supplies the Sartorius at the median edge, and enters the abruptly defined interlaminate space. It becomes superficial within the upper third of the thigh, and is distributed to the skin in front and on the inner side of the thigh and knee-joint, where it may anastomose with an occasional cutaneous branch of the obturator. It divides into two portions about four inches below Poupart's ligament, one of these soon separating into two smaller branches. These branches descend side by side on the fore part of the thigh, supplying the integument as far as the inner side and front of the patella. The middle cutaneous nerve anastomoses with the crural branch of the genito-crural nerve, and also with the internal cutaneous.

The deeper and outer group of the branches of the anterior crural nerve divides into branches supplying the Quadriceps Extensor muscle and often the Pectineus, and into a cutaneous branch, the internal saphenous nerve.

The branches of the deep division are as follows:—

The nerve to the Vastus Externus.—This nerve gives off a long slender articular filament, which reaches the knee and penetrates the fibrous capsule of the joint.

The nerve to the Vastus Internus.—This nerve, which is often double, before entering the muscle, gives off a small branch, which accompanies a branch of the anastomotic artery to the knee-joint, to supply the synovial membrane beneath the ligamentum patellæ. It sends off a periosteal branch.

The nerve to the Rectus.—Besides supplying the Rectus muscle, this nerve yields a nutrient branch which enters the nutrient canal in company with the artery of the same name, as well as several twigs; these twigs, according to Henle, pass transversely outward, in company with a branch of the external circumflex artery, to the hip-joint.

The Internal Saphenous Nerve (long saphenous nerve).—This is the largest branch of the anterior crural. It lies in the groove between the Vastus Internus and Adductor Magnus, and is covered by the Sartorius and the fascia lata. It passes downward and inward within the femoral sheath as far as the annular opening in the Adductor Magnus. It here pierces the anterior wall of the sheath, lying between the femoral artery and vein, and passes to the outer side of, or beneath the Sartorius nearly to the knee, where it becomes superficial between the tendons of the Sartorius and Gracilis. From this point, in company with the long saphenous vein, it passes downward along the inner side of the anterior border of the tibia to the ankle, and then to the dorsum of the foot. Its terminal branches are distributed to the latter region, and anastomose along the inner border of the foot with the corresponding branches of the peroneal cutaneous.

At the middle of the thigh the internal saphenous sends a branch to the obturator nerve in common with the internal cutaneous. Near the knee-joint it sends another to the articulation; while several superficial branches cross transversely the inner side of the joint and the front of the patella. Below the knee it sends a branch to the inner aspect of the calf of the leg; occasionally another to the lower third of the leg, which descends along the inner margin of the tibia; and one to the tarsal articulations.

The long saphenous nerve usually passes through the annular opening in the Adductor Magnus with the artery and vein, but it soon returns to the groove between the Vastus Internus and the Adductor Magnus.

The middle and internal cutaneous nerves supply the great saphenous vein. The posterior cutaneous branch

supplies the lesser saphenous vein. The anterior crural nerve supplies the femoral artery.

Variations.—The external cutaneous may accompany the anterior crural nerve.[1]

Remarks.—The intra-pelvic portion of the anterior crural nerve may be compressed by the fœtal head. The Sartorius muscle may escape in paralysis of the other muscles supplied by the anterior crural nerve. Paralysis of the Quadriceps Extensor may be associated with paralysis of the Tibialis Anticus in cases of lead palsy.[2] Clinical writers include, among the rare causes which may induce paralysis of the entire anterior crural nerve, pressure on the *cauda equina* from a tumor or blood-clot, inflammation of the Psoas muscle, and psoas abscess. As far as the author knows, no account of any dissection of lesion of the anterior crural nerve has been recorded. For paralysis of the muscles supplied by this nerve, see p. 463.

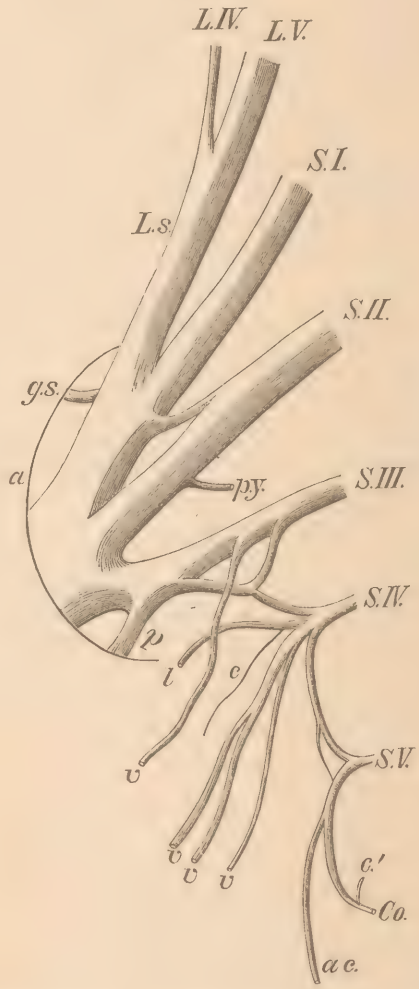
THE SACRAL AND COCCYGEAL NERVES.

These pursue a longer course within the vertebral canal than any other spinal nerves. They arise from the lower extremity of the spinal cord, and constitute the *cauda equina*. Each divides into an anterior and a posterior branch within the vertebral canal. The anterior branches escape through the anterior sacral foramina (with the exception of the last, which effects exit between the sacrum and the coccyx), and enter the pelvic cavity to constitute the sacral plexus.

Anterior Branches.—The sacral plexus is thus made up of the lumbo-sacral nerve, of the anterior branches of the three upper sacral nerves, and of a branch from the fourth and one from the coccygeal nerve. They unite by short trunks with the four sacral ganglia and the coccygeal ganglia. The roots of this plexus decrease in size from above downward. Scarcely any diminution is noticed in the first and second; the others, however, diminish rapidly, the last being very small. This arrangement might be anticipated when the shape of the sacrum is considered.

The roots converge to form a flat triangular mass with its base at the last lumbar vertebra and the sacral foramina. The greater part of the plexus contributes to form the great sciatic nerve. It is placed between the inferior border of the Pyriformis muscle and the origin of the Coccygeus.

Fig. 125.



A diagrammatic drawing of the Sacral Plexus. *L. s.* Lumbo-sacral nerve. *g. s.* Superior Gluteal. *p.* Pudic nerve. *a.* Border of the great sacro-sciatic foramen. *p. y.* Nerve for Pyriformis. *l.* Nerve for Levator Ani. *c.* Nerve for Coccygeus. *v v v.* Visceral branches. *L. IV.–L. V.* Fourth and fifth lumbar nerves. *S. I.–S. V.* The five sacral nerves. *Co.* Coccygeal nerve. *c'.* Its branch of communication with the main trunk. *a c.* Ano-coccygeal nerve.

[1] Gruber, H. & S., 1879.

[2] G. Remak. Arch. f. Psychiatrie u. Nervenkr. 1876, vi. I.

EXPLANATION OF PLATE LXXXVIII.

Fig. 1. The superficial nerves and lymphatics of the front of the upper extremity.

Fig. 2. The same, of the front of the thigh.

Fig. 3. The same, of the front of the leg and dorsum of the foot.

Fig 1

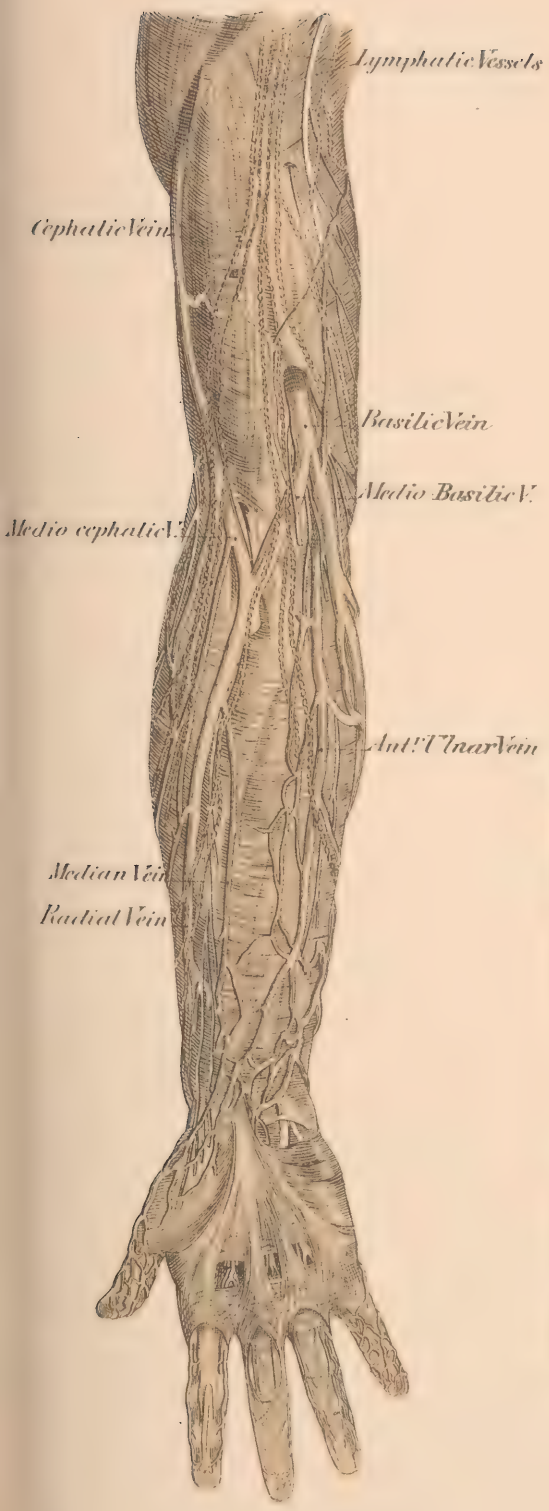
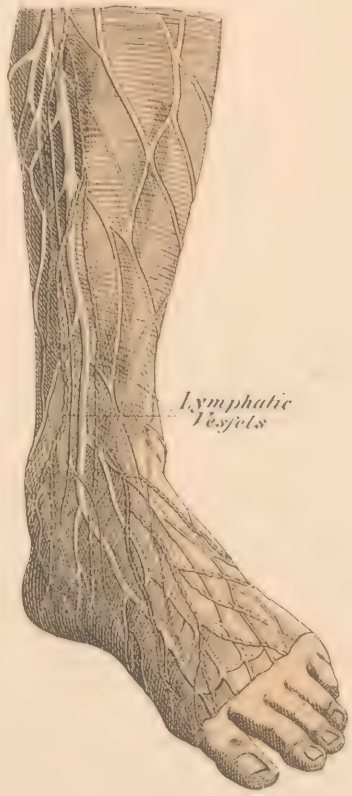


Fig 2



Fig 3.



T. Sinclair & Son, Lith.

The first sacral nerve advances along the upper, the third along the inferior margin of the Pyriformis; the second pierces this muscle; the fourth and fifth lie at their exit from the sacral foramina upon the tendon of the Coccygeus. Specimens have been described in which only the three upper sacral nerves united to form the great sciatic nerve. The fourth often does not contribute to the plexus.

Posterior branches. The posterior branches of the sacral nerves, from the first to the fourth, escape through the posterior sacral foramina beneath the Multifidus Spinæ muscle, and unite to form a loose plexiform arrangement, the *posterior sacral plexus* (Hyrtl). The internal branches are very small, and supply the Multifidus Spinæ. Of the external branches one from the third sacral sends a twig to the ilio-sacral junction, as well as to the adjoining fibrous tissues. Other branches penetrate the Gluteus Maximus to supply the skin over the region of the sacrum and coccyx.

The fifth sacral nerve has no anterior branch. Passing down upon the anterior surface of the Coccygeus to the tip of the coccyx, it is distributed to the integument over the back of that bone, where it joins the coccygeal nerve.

The Coccygeal Nerve, sometimes called the sixth sacral nerve, arises from the spinal cord at its lower end, and accompanies the filum terminale to its free extremity. It is free within the vertebral canal from below the third sacral segment. It is exceedingly delicate, and divides into two branches, an anterior and a posterior. The *anterior*, after passing through a foramen between the side of the coccyx and the lateral coccygeal ligament, joins a branch from the fifth sacral. From the trunk formed by this union a twig passes to the Coccygeus muscle, and a second, the ano-coccygeal nerve, to the skin over the tip of the coccyx and adjacent parts.

The *posterior* branch, the weaker of the two, joins a branch from the fifth sacral nerve, and supplies the skin over the back of the coccyx.

The experimental researches of D. Ferrier and J. B. Yeo, taken in conjunction with the dissections of M. Féré,[1] yield the following results:—

The peroneal nerve can be traced to the posterior part of the posterior bundle of the *fourth lumbar* nerve, and to the *lumbo-sacral nerve*, which together form a stem passing to the *first sacral nerve*. Stimulation of the *first sacral nerve* causes flexion of the leg, plantar flexion of the foot, and flexion of all the toes at the proximal phalanges, as well as of the distal phalanx of the great toe.

[1] See Lumbar Plexus.

The peroneal, in addition to the above, contains a small bundle from the *second sacral nerve*, and a filament from the *third sacral nerve*. The tibial also receives filaments from the second and third sacral nerves. Stimulation of the *second sacral nerve* causes contraction of the intrinsic muscles of the foot, resulting in adduction and flexion of the great toe, with flexion of the proximal, and extension of the distal phalanges.

The anterior tibial nerve also receives fibres from the *fourth sacral nerve*.

The Branches of the Sacral Plexus are—

Superior Gluteal,
Muscular,
Small Sciatic,
Inferior Gluteal,
Pudic,
Great Sciatic,
Perforating Cutaneous.

THE SUPERIOR GLUTEAL NERVE.

The Superior Gluteal Nerve arises from the posterior surface of the lumbo-sacral nerve, and receives an accession from the posterior surfaces of the first and second sacral nerves. It escapes above the upper border of the great sciatic notch to gain the dorsum of the ilium, where it divides into two branches, the superior and the inferior. The *superior branch*, the smaller of the two, crosses between the Gluteus Minimus and Gluteus Medius, along the course of the inferior semicircular line, accompanying a branch of the gluteal artery, and giving off branches which supply for the most part the Gluteus Medius. The *inferior branch* crosses the Gluteus Minimus midway between the inferior semicircular line and the great trochanter, supplies filaments to the Gluteus Medius and Gluteus Minimus, and terminates on the Tensor Vaginæ Femoris.

MUSCULAR BRANCHES OF THE SACRAL PLEXUS.

The nerve to the Pyriformis, the shortest of all the branches, arises from the posterior part of the sacral plexus, or from the third sacral nerve. It divides on a level with the great sciatic notch to supply the Pyriformis from its deep or under side. It is often double.

The nerve to the Obturator Internus arises at the junction of the lumbo-sacral and first sacral nerves, crosses the spine of the ischium, and, re-entering the pelvis, through the lesser sacro-sciatic foramen, supplies the Obturator Internus muscle from its inner side.

The nerve to the Superior Gemellus is a small branch arising from the lower anterior part of the plexus at the level of the origin of the great sciatic nerve.

The nerve to the Quadratus Femoris and Inferior Gemellus arises from the lower anterior part of the plexus. It passes down, concealed by the sciatic nerve, between the latter and the tuberosity of the ischium. It sends a small collateral branch to the Inferior Gemellus, and terminates in the deep or anterior surface of the Quadratus Femoris. An articular branch to the hip-joint, sometimes derived from the great sciatic, may be given off by this nerve; and, according to Cruveilhier, it also supplies periosteal and osseous branches to the tuberosity of the ischium.

THE SMALL SCIATIC NERVE.

The Small Sciatic Nerve (posterior cutaneous nerve of the thigh) supplies the skin over the lower part of the Gluteus Maximus muscle; the muscle itself; the skin over the posterior and inner aspects of the thigh and the leg; as well as that over the inner portion of the thigh and the external genitals. It arises commonly by two roots from the posterior surface of the second and third sacral nerves, receiving a branch also from the inferior gluteal nerve. It escapes from the great sacro-sciatic foramen below the Pyriformis, and a little to the inner side of the great sciatic nerve. While under cover of the Gluteus Maximus, it sends several conspicuous branches to that muscle. At the lower border of the Gluteus Maximus, it becomes subaponeurotic, and divides into two superficial sets of branches; one directed outward and backward, the other inward. The *external* set distributes cutaneous (gluteal cutaneous) branches upward over the lower part of the Gluteus Maximus.

The *internal* terminal branch (inferior pudendal nerve) lies beneath the femoral fascia at the lower margin of the Gluteus Maximus. It passes inward below the tuberosity of the ischium and across the origin of the femoral flexor muscles, to divide into two sets of branches, one of which descends a short distance along the inner aspect of the thigh, while the other (the main nerve) continues forward in the superficial fat of the perineum, to the front and lateral surfaces of the scrotum. According to some authors, it passes to the penis. It communicates with the perineal branch of the internal pudic nerve, and sends a few unimportant twigs backward to the perineum. In the female the pudendal branch supplies the labium majus.

The other more important branches (posterior cutaneous, femoral cutaneous), constituting the main divisions of the small sciatic nerve, pass down the posterior aspect of the thigh as far as the popliteal space, where an internal branch is given off to supply its inner margin, and another which, perforating the fascia at the posterior portion of the calf, descends in company with the short saphenous vein to join the short saphenous nerve below the middle of the leg. While within the posterior femoral region, the small sciatic sends off lateral cutaneous branches of which the inner are the more numerous.

Variations.—The inferior pudendal nerve may pierce the great sacro-sciatic ligament to enter the ischio-rectal fossa.[1]

THE INFERIOR GLUTEAL NERVE.

The Inferior Gluteal Nerve (Plate LXXXIX., fig. 2) arises from the posterior aspect of the plexus by fibres which are traceable to the lumbo-sacral nerve and to the first and second sacral nerves. The nerve passes beneath the Pyriformis muscle to supply the lower part of the Gluteus Maximus muscle.

Variations.—The inferior gluteal nerve may be a branch of the small sciatic, with which it was formerly described.

THE PUDIC NERVE.

The Pudic Nerve is the nerve of the penis in the male, and of the clitoris in the female, supplying the muscles, skin, and mucous membrane pertaining to these organs. The nerve arises from the second, third, and fourth sacral nerves, and occasionally from the fifth. These roots have a plexiform arrangement, and receive branches from the sympathetic system. The main nerve resulting from their union is a flattened cord, which accompanies the internal pudic artery. It passes along the outer wall of the ischio-rectal fossa in the sheath of the obturator fascia, leaves the pelvis at the great sacro-sciatic foramen below the Pyriformis muscle, and winds round the spine of the ischium to re-enter the pelvis through the lesser sacro-sciatic foramen.

The branches of the pudic nerve are as follows:—

Inferior Hemorrhoidal,[2]
Perineal,
Dorsal Nerve of Penis.

[1] Bankert, Smith, and Phillips, St. Thomas's Hosp. Rep., 1874, v. 285.

[2] The pudic nerve is described by Henle, Luschka, Quain, Meckel, and Schwalbe as including the inferior hemorrhoidal nerve. Other systematic writers describe the inferior hemorrhoidal nerve as a distinct branch of the sacral plexus.

The Inferior Hemorrhoidal Nerve (external hemorrhoidal nerve) passes across the ischio-rectal fossa in company with the corresponding vessels, and lies in front of the lower border of the Gluteus Maximus. It reaches the lower part of the rectum, where it joins the superficial perineal branch of the internal pudic, and the inferior pudendal branch of the lesser sciatic, and supplies the External Sphincter muscle.

Variations.—The inferior hemorrhoidal nerve is often a distinct branch of the sacral plexus, or of the plexiform arrangement described under the pudic nerve.

The Perineal Nerve lies below the pudic artery, and descends between the obturator fascia and the Obturator muscle to the anterior portion of the perineum, being continued thence forward and downward, between the Ischio-cavernosus and Bulbo-cavernosus muscles, to the scrotum, upon the skin of which and upon the dartos and the skin of the upper basal fourth of the penis it terminates. The nerve sends a *superficial* branch to the skin in front of the anus, where it anastomoses with the inferior hemorrhoidal nerve; a *collateral* branch; a *deeper muscular* branch, which supplies the Ischio-cavernosus, the Accelerator Urinæ and Transversalis Perinei muscles; and an important branch to the spongy body. The last-named nerve passes through nearly the entire length of the spongy body, and supplies the urethral mucous membrane.

Quain and Cruveilhier assert that this nerve sends small twigs to the Levator Ani muscle. Cruveilhier describes an external perineal branch which perforates the sacro-sciatic ligament, passes by the internal surface of the tuberosity, runs along the crus of the cavernous body, and is lost in the dartos.

J. Hilton[1] narrates a case of a gentleman who had been accustomed to sit upon a hard and uneven seat, and who complained of pain crossing the ascending ramus of the ischium to one side of the penis. The pain was associated with the presence of a whipcord-like thickening in the soft parts about the tuberosity and the ascending ramus of the ischium. Pressure on this mass excited an attack of the pain, which was referred by the recorder to the *perineal nerve*. The neuralgia was cured by applications of nitric acid over the indurated tract, and by relieving the habitual pressure against the spot. A somewhat similar case was seen by him[2] in which the perineal nerve in a female was the seat of persistent neuralgia, the result of pressure against the nerve near the tuberosity of the ischium by a bursal tumor.

The Dorsal Nerve of the Penis passes upward between the Levator Ani and Obturator Internus muscles, pierces the uro-genital diaphragm between the two layers of the deep perineal fascia, and afterwards the suspensory ligament to reach the back of the penis, along which it passes, lying to the upper side of the dorsal artery, to the glans. It forms two distinct nerves: the internal is the continuation of the main nerve, and is lost in the glans penis and prepuce; the outer breaks up into numerous small branches for the integument of the distal three-fourths of the penis, and for the cavernous bodies. The last-named branches are believed to unite with filaments of the sympathetic, and aid in the supply of the urethral mucous membrane. In the female the clitoris, portions of the wall of the vagina, and the labia receive filaments from the superficial perineal nerve.

THE GREAT SCIATIC NERVE.

The Great Sciatic Nerve (Plate LXXXIX., fig. 2) is the largest nerve in the body, and supplies the muscles of the back of the thigh, and the muscles and skin of the leg and foot, with the exception of that portion of the skin which is supplied by the internal saphenous nerve. It is a continuation of the lower part of the sacral plexus, and is composed of the lumbo-sacral, a branch of the fourth lumbar, the anterior branches of the first, second, and third sacral nerves, and a branch of the fifth. The nerve presents the form of a flattened band, about half an inch in thickness at its origin, which escapes at the sacro-sciatic foramen, and gradually narrows as it descends to terminate at the lower third of the thigh by division into the internal and external popliteal nerves. Within the buttock the nerve lies upon the Gemelli muscles and the tendon of the Obturator Internus, about midway between the great trochanter and the tuberosity of the ischium, and is covered by the Gluteus Maximus muscle. Along the posterior part of the thigh the nerve lies upon the Quadratus Femoris and the Adductor Magnus, and is covered by the hamstring muscles, more especially by the long head of the Biceps Flexor. Should the nerve reach the upper part of the popliteal space before division, it lies superficial to the popliteal vessels a little to their outer side, and is without muscular covering.

The branches of the great sciatic nerve in the thigh are:—

Muscular,
Articular.

[1] On Rest and Pain, 1877, 220. This nerve may have been the pudendal branch of the small sciatic.

[2] Ibid., 223.

The Muscular Branches are slender and are confined to the posterior flexors, to the Quadratus Femoris and Gemelli, and to the lower part of the Adductor Magnus. The nerves to the Quadratus Femoris and Gemelli commonly arise from a single trunk. The Biceps receives occasionally two branches, one to the centre and lower part, and a second to the upper portion. The branch to the Semimembranosus commonly supplies the median border of the Adductor Magnus. The Semimembranosus generally receives two branches, one for the fibres above, and one for those below the inscription.

The Articular Branches are confined to the hip-joint and the knee-joint, into which they enter from behind. The branch to the hip-joint is often supplied by the branch to the Quadratus Femoris, but when not so derived, it springs independently from the main nerve. The nerve to the knee occasionally arises from the external popliteal nerve.

The finger passed under the ham-strings lifts up the nerve with the muscles.

Variations.—The variations of the sciatic nerve pertain to the variations of the internal and external popliteal divisions, under the headings of which they are described.

Remarks.—From a clinical point of view the sciatic nerve may be studied (*a*) as the nerve lies in the pelvis; (*b*) as it escapes from the pelvis; and (*c*) as it lies behind the neck of the femur.

(*a*) The nerve may be compressed by the fœtal head. It may be involved in abscess caused by caries of the sacro-iliac articulation; and neuralgia along the course of the nerve may in this way be caused.—The sciatic nerve may be severed from the roots composing it by violent traction. The following remarkable case exhibiting this lesion is reported by G. Pollock.[1] A child, eight years old, was run over by a street-cab, and the leg, in consequence of becoming caught in the wheel, was severed from the thigh at the knee-joint. The sciatic nerve was torn away from its attachments to the thigh, and was seen as a cord, measuring seventeen inches in length, attached to the leg. After the death of the child, which took place on the second day after the accident, the position of the sciatic nerve in the thigh was occupied by extravasated blood, and some of the branches of the sacral plexus in the pelvis were shreddy and broken off close to the anterior sacral foramina.

(*b*) In forced flexion of the thigh, while the leg is extended, the nerve may be stretched as it passes through the great sacro-sciatic foramen. Its fibres, indeed, may give way.

(*c*) The nerve was found, in a case of dislocation of the head of the femur into the ischiatic notch reported by R. Quain,[1] to turn over the neck of the femur, and to come in contact with the bone between the ends of the ruptured Quadratus Femoris. Swan found the nerve injured in a case of fracture of the neck of the femur.

The nerve is a frequent seat of rheumatic and gouty affections.

The continuations and branches of the great sciatic nerve will be described under the following heads:—

Continuations { The Internal Popliteal Nerve, / The Posterior Tibial Nerve, / The Plantar Nerves.

Branches { Muscular Branches,[2] / Articular Branches, / External Popliteal Nerve.

THE INTERNAL POPLITEAL NERVE.

The Internal Popliteal Nerve (Plates LXXXIX., fig. 2; XC., fig. 1), the larger of the two divisions of the sciatic, passes nearly vertically downward through the popliteal space, beneath the fascia and a thin layer of adipose tissue. At the lower part of the popliteal space it passes between the two heads of the Gastrocnemius muscle, and lies between them and the Popliteus, beyond the lower border of which muscle it receives the name of the posterior tibial nerve.

The branches of the Internal Popliteal Nerve are as follows:—

[1] Trans. Path. Soc. Lond., 1857, viii. 392.

[1] Medico-Chir. Trans., xxxi. 344.

[2] The muscular and articular branches are described, *supra*, p. 571.

EXPLANATION OF PLATE LXXXIX.

Fig. 1. A dissection exhibiting the nerves of the groin and the anterior and median aspects of the thigh.

Fig. 2. A dissection exhibiting the nerves of the buttock and the posterior aspect of the thigh.



Fig 1

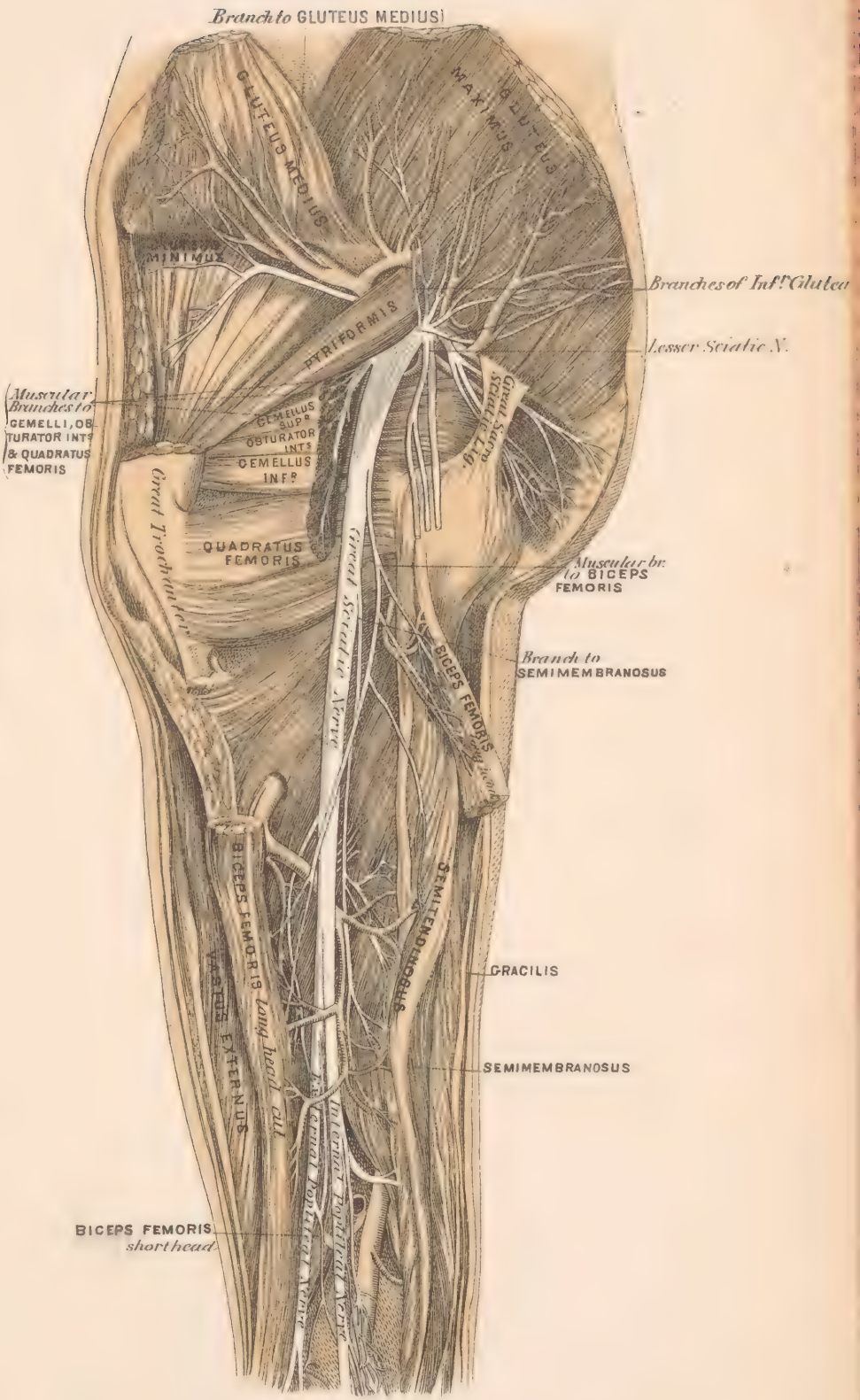


Fig 2

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Short Saphenous,
Muscular,
Articular.

The Short Saphenous Nerve (external saphenous nerve) arises from the internal surface of the internal popliteal, near the junction of the lower and middle thirds of the thigh, viz., at the upper part of the popliteal space, and passes down parallel with it to the Gastrocnemius, which it pierces at the septum between the two heads; or, lying simply within the groove formed at their junction, extends as far as the middle of the calf, where it passes through the fascia, and is soon joined by the *peroneal communicating* branch from the external popliteal. Increased in size by this union, it runs downward subcutaneously in company with the short saphenous vein to the outer side of the beginning of the tendo Achillis, and thence passes round the external malleolus and along the outer border of the foot. It sends a few filaments to the skin at the side of the heel, and supplies the lateral border of the little toe, and sometimes, in addition, that of the fourth toe, afterwards anastomosing with branches of the dorsal cutaneous nerve. It supplies the lateral and anterior portions of the ankle-joint and the ligaments of the sinus tarsi.

The Muscular Branches are designed for the Gastrocnemius and Soleus, the Plantaris and the Popliteus. Those for the inner head of the Gastrocnemius are usually two in number. The nerve for the outer head gives off also a branch to the Soleus. This branch may, however, arise separately. The nerve for the Plantaris often arises in common with the branch to the median head of the Gastrocnemius, or it may arise independently from the main trunk. It sends minute filaments in addition to the knee-joint. The nerve to the Popliteus pursues an unusual course. It arises to the outer side of the popliteal vessels, winds around the lower border of the muscle, and is lost in numerous branches upon its anterior surface. Several branches may be distributed to the tibio-fibular articulation and to the periosteum of both the tibia and the fibula.

The Articular Branches. In addition to the branch to the ankle-joint, the posterior tibial supplies the knee-joint by three branches. Two of these follow the course of the superior and inferior internal articular arteries; the other accompanies the azygos artery.

Variations.—The articular branches exhibit great variety. Henle and Rüdinger describe a plexus lying upon the popliteal vessels, formed by the union of these branches with a filament of the external popliteal nerve. The short saphenous nerve may supply the whole of the fifth and one-half of the fourth toe, or the whole of the fourth and fifth toes and one-half of the third.

When of high origin the internal popliteal nerve represents the trunk of the sciatic and lies below the Pyriformis. The internal and external popliteal nerves often lie within the same sheath in the thigh and simulate the trunk of the sciatic nerve. Examples of such association are to be included under instances of high division of the sciatic nerve.

Remarks.—John Bell describes reflex phenomena in the leg and foot from contusions of this nerve.—A case is reported by Charles H. Moore[1] in which an arterio-venous cyst was formed within the left internal popliteal nerve, necessitating amputation of the limb above the knee.

THE POSTERIOR TIBIAL NERVE.

The Posterior Tibial Nerve is the continuation of the trunk of the internal popliteal. It extends from beneath the arch of the Soleus along the posterior part of the leg, upon the Tibialis Posticus muscle, being accompanied by the posterior tibial artery. It lies at first to the inner side of the artery, but about an inch below the head of the fibula, crosses to the outer side, and continues in this relation as far as the internal malleolus, about which it turns in the same sheath with the posterior tibial artery and vein. Upon the body of the calcaneum, it divides into its terminal branches, the *internal* and *external plantar* nerves.

The branches of the Posterior Tibial Nerve in the leg are—

Muscular,
Osseous,
Articular,
Cutaneous.

The Muscular Branches. At the upper part of the nerve, branches are given off to supply the Tibialis Posticus and the Soleus. About the middle of the leg arise branches for the Flexor Longus Pollicis and the Flexor Longus Digitorum.

The Osseous Branches supply the interior of the tibia through the nutrient canal, and send filaments to the periosteum. A second branch supplies twigs to the periosteum of the fibula, and sends a branch through the nutrient foramen.

The Articular Branches. The posterior tibial nerve sends branches to the ankle-joint and to the tibio-fibular articulations. The branch to the inferior tibio-fibular articulation passes down upon the interosseous membrane, in part upon the membrane, and in

[1] Med.-Chir. Trans., 1866, xlix. 29.

part between its layers.[1] The articular branches also supply the walls of the posterior tibial artery.

A Cutaneous Branch supplies the skin on the inner side of the heel and the posterior portion of the plantar surface.

THE PLANTAR NERVES.

The Plantar Nerves are two in number, as follows:—

The Internal Plantar,
The External Plantar.

These nerves are about equal in size, though the internal plantar nerve is generally described as being the larger. The nerves thus present a contrast to the plantar arteries, of which the external is much the larger.

The Internal Plantar Nerve has a distribution resembling that of the median nerve in the hand. It turns around the inner malleolus, and lies in a groove upon the inner surface of the calcaneum. It passes above the Abductor Pollicis, between that muscle and the Flexor Brevis Digitorum, in company with the internal plantar artery, and divides into two terminal branches, the internal and the external.

The *internal branch* (median branch, first digital nerve) leaves the median side of the nerve in the neighborhood of the scaphoid bone, passes forward beneath the tendon of the Abductor Pollicis, and supplies this muscle and the median head of the Flexor Brevis Pollicis, as well as the skin along the median border of the foot and the great toe.

The *external branch* (lateral branch) is the larger of the two, and lies between the anterior portion of the Flexor Brevis Digitorum and the plantar fascia. It divides, about on the line of the tarso-metatarsal joint, into three branches, named the second, third, and fourth digital nerves, which supply the delicate structures of the tips of the toes, and send branches to the matrix beneath the nails.

The *second digital nerve* leaves the main nerve at about the middle of the sole of the foot, runs forward across the first interosseous space, and divides into two branches at the metatarso-phalangeal joint, to supply the opposed surfaces of the great and second toes. Before division it sends a branch to the first Lumbrical muscle.

The *third digital nerve* usually arises near the second. It is directed obliquely outward and forward across the inner border of the Flexor Brevis Digitorum, dividing opposite the second metatarso-phalangeal joint to supply the opposed surfaces of the second and third toes. It sends a branch to the second Lumbrical muscle.

The *fourth digital nerve*, arising near the third, passes still more obliquely outward and forward. It crosses the Flexor Brevis Digitorum, and, dividing into two branches, supplies the opposed surfaces of the third and fourth toes. It sends an inconstant communicating branch to the superficial division of the external plantar nerve.

Remarks.—The internal plantar nerve has been resected for chorea with a favorable result.

The External Plantar Nerve has a distribution resembling that of the ulnar nerve in the hand, being distributed to the little toe and half of the fourth, as well as to several of the intrinsic muscles of the foot. The nerve is directed obliquely outward, and passes between the Flexor Brevis Digitorum and the Flexor Accessorius in company with the external plantar artery. It then lies upon the calcaneo-cuboid ligament, and gains the space between the Flexor Brevis Digitorum and the Abductor Minimi Digiti, where it divides into its terminal branches, the superficial and the deep branch. The *superficial branch* is directed forward and outward, and divides into two branches. One of these, the *internal*, supplies the opposed surfaces of the fourth and fifth toes, while the other, the *external*, gives branches to the Flexor Brevis Minimi Digiti, as well as to one or both of the Interosseous muscles of the fourth metatarsal space, and supplies the outer border of the fifth toe.

The *deep branch* (muscular branch) lies beneath the tendons of the flexor muscles and the Adductor Pol-

[1] H. J. Halbertsma, Archiv f. Anat., 1847, xv. 303.

EXPLANATION OF PLATE XC.

Fig. 1. A dissection exhibiting the nerves of the back of the leg and the sole of the foot.

Fig. 2. A dissection exhibiting the nerves of the sole of the foot.

Fig. 3. A dissection exhibiting the nerves of the antero-lateral aspect of the leg and of the back of the foot.

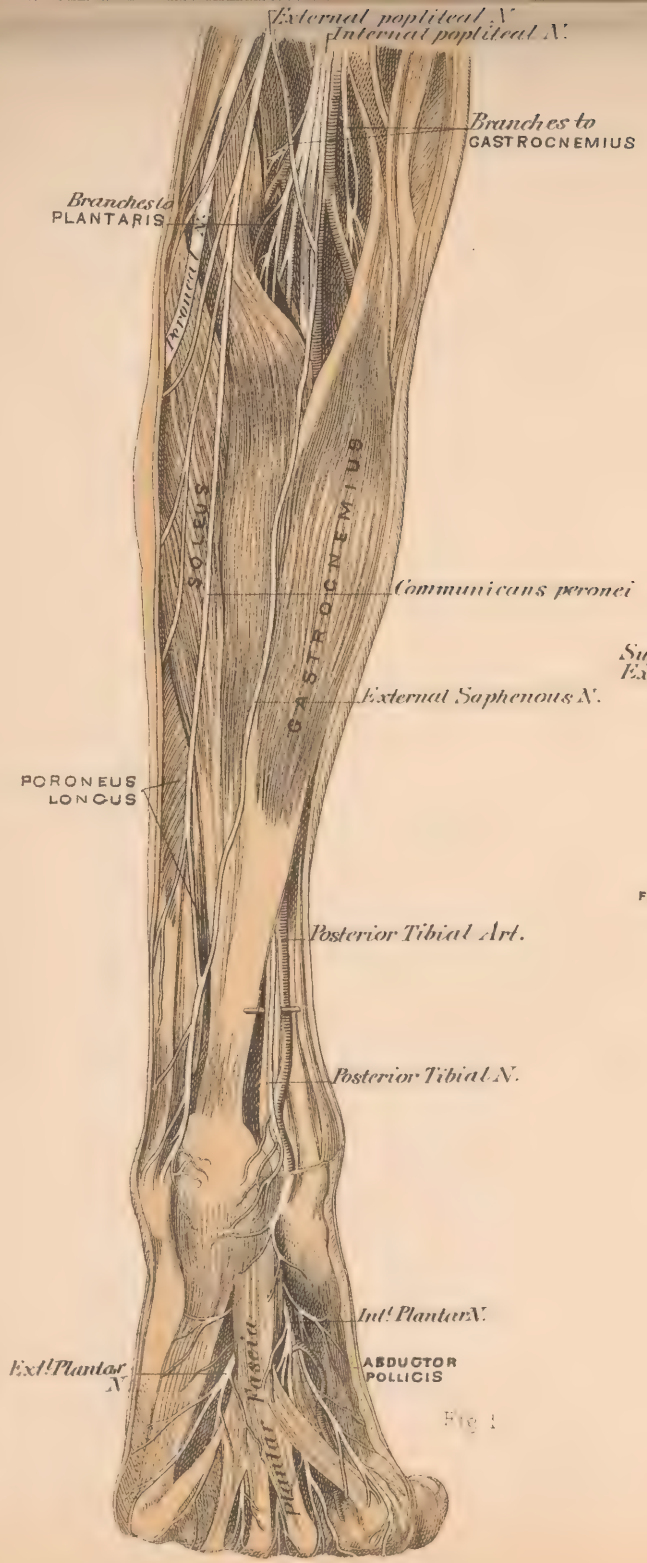


Fig. 1

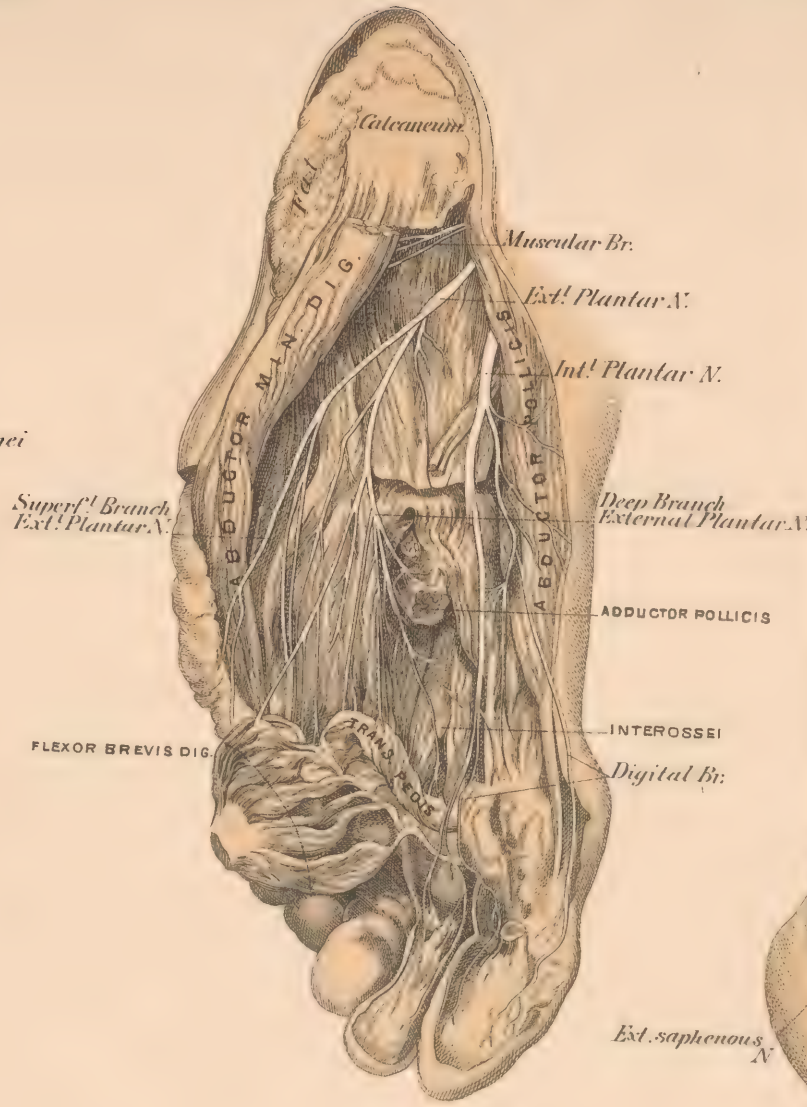


Fig. 2.

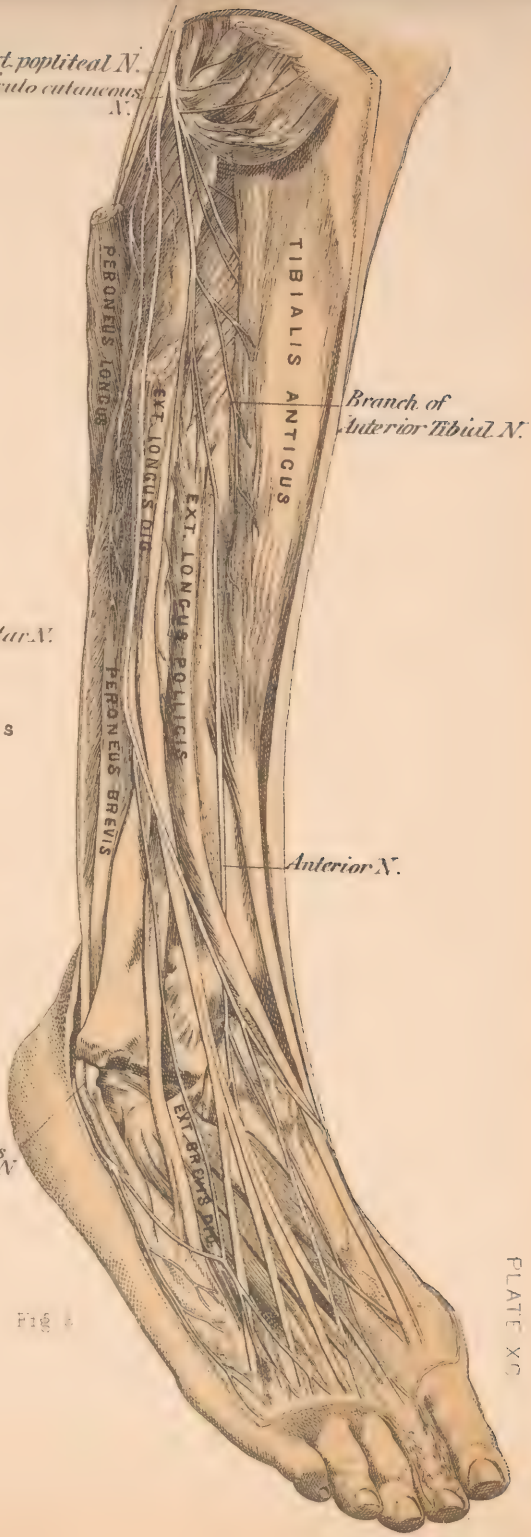


Fig. 3

PLATE XC

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licis, supplying the Interossei muscles, both dorsal and plantar, the Adductor Pollicis, the Transversalis Pedis, the outer head of the Flexor Brevis Pollicis, and the Lumbrical muscles.

Before division the external plantar nerve supplies the Abductor Minimi Digiti and the Flexor Accessorius.

Variations.—The lateral filament of the superficial branch of the external plantar nerve may arise from the deep branch. The deep branch may supply the Interossei from the second to the fourth, the first Interosseous muscle being supplied by the anterior tibial nerve. This is given as the normal arrangement by Henle and W. Krause.

The Adductor Pollicis may be supplied by the internal plantar nerve. The external plantar nerve may supply the Adductor Minimi Digiti. The Flexor Brevis Minimi Digiti may be supplied by the deep branch. (W. Krause.)—According to Cruveilhier, the internal plantar nerve may perforate the Flexor Brevis Digitorum at its posterior extremity, and may be protected on the calcaneum by a fibrous canal.

The innervation of the Lumbricales is subject to variation. Henle and Quain assign the third and fourth muscles to the external plantar nerve, and the first and second to the internal plantar. W. Krause, who has been followed in the text, assigns all the Lumbricales to the external plantar nerve.

THE EXTERNAL POPLITEAL NERVE.

The External Popliteal Nerve (peroneal nerve), the most superficial trunk of its size in the body, passes from its origin in the sciatic nerve obliquely downward and outward, close to the Biceps muscles and in a sulcus to its inner side. Passing along the outer side of the popliteal space, it crosses the outer head of the Gastrocnemius and reaches the head of the fibula, where it passes through the origin of the Peroneus Longus, and abruptly divides into its terminal branches, the musculo-cutaneous and the anterior tibial nerves.

The branches of the external popliteal nerve are—

Collateral	{ Articular. { Peroneal Communicating.
Terminal	{ Musculo-Cutaneous. { Anterior Tibial.

The Articular Branches, as a rule, two in number, arise beneath the tendon of the Biceps muscle, and terminate in the capsule of the knee-joint.

According to Quain, these branches may arise from a common trunk, or the upper may arise from the great sciatic. Henle ascribes to it a small muscular branch to the Biceps muscle.

The Peroneal Communicating Nerve arises within the popliteal space, and descends to become superficial about the middle of the leg, where, as a rule, it joins the external saphenous nerve, whence its name. It is variable in its course, and may continue separately along the outer and posterior part of the leg as far as the ankle. It often yields a malleolar branch which winds beneath the external malleolus to supply the adjacent parts, and to join a filament from the musculo-cutaneous nerve.

The Musculo-Cutaneous Nerve (superficial peroneal nerve) passes downward at first within the Peroneus Longus muscle, between the Extensor Longus Digitorum and the Peroneus Longus, as far as the middle or lower third of the leg, where it pierces the fascia and becomes superficial. Continuing its course, and following the direction of the Extensor Longus Digitorum, it divides into two branches, which reach the dorsum of the foot, and are arranged as follows:—

The *internal* branch, the larger of the two, passes forward, and is distributed to the inner side and dorsum of the foot, to the skin of the ankle, to the inner side of the great toe, and to the opposed surfaces of the second and third toes. It unites with the terminal branches of the long saphenous nerve.

The *external* branch subdivides into three or four branches, which are distributed to the skin of the dorsum and contiguous borders of the second and third, and the third and fourth toes, and to the inner border of the fifth toe. The contiguous borders of the first and second toes are usually supplied by the internal branch of the anterior tibial nerve, but in its absence this branch of the musculo-cutaneous supplies them. The nerve sends muscular branches to the Peroneus Longus and Peroneus Brevis. It also gives off a malleolar branch, which passes between the external malleolus and the skin.

Variations.—The external popliteal nerve may, in case of high division of the great sciatic nerve, arise from between the divisions of a cleft Pyriformis muscle.

Remarks.—The external popliteal nerve is one of the first nerves to lose excitability after death.—It may be easily felt beneath the skin in thin persons, lying to the inner side of the tendon of the Biceps muscle, and behind the head of the fibula. It may become tense and prominent in cases of long-standing contraction of the knee-joint, and may be wounded in dividing the Biceps tendon. After the tendon has been divided, the nerve springs up so as to occupy its place, feeling as tense as the tendon did before division. The inexperienced operator may conclude

that the tendon has not been completely divided, and under these circumstances the knife may be re-introduced, and the nerve divided.

THE ANTERIOR TIBIAL NERVE.

The Anterior Tibial Nerve (deep peroneal nerve) passes downward through the upper part of the Extensor Longus Digitorum to reach the space between this muscle and the Tibialis Anticus. It here lies upon the interosseous membrane in relation with the anterior tibial vessels, first to the outer side of the artery, then upon it and near the ankle, again to its outer side; and finally, passing beneath the annular ligament, it lies upon the anterior portion of the capsule, where it divides into its terminal branches, internal and external. While pursuing the above course, it sends numerous muscular branches to the Tibialis Anticus, Extensor Longus Digitorum, Extensor Brevis Digitorum, Extensor Proprius Pollicis, and Peroneus Tertius.

The *internal* branch, the true continuation of the nerve, passes forward between the Extensor Brevis Digitorum and the Extensor Proprius Pollicis and upon the first interosseous space, as far as the metatarso-phalangeal articulation, where it gains the fascia, and divides into branches which supply the opposed surfaces of the first and second toes. In the absence of this branch of the anterior tibial, the musculo-cutaneous nerve supplies the surfaces just mentioned.[1] A recurrent branch supplies the outer portion of the knee-joint.

The *external* (tarsal) branch passes beneath the Extensor Brevis Digitorum and over the tarsus. Some of its branches are lost within the fibres of the muscle last named. In addition it sends branches to the dorsal portion of the articulations of the foot, and sometimes to the first interosseous muscle. (*See* Variations.) Both the above branches, according to Sappey, are covered not only by the dorsal aponeurosis of the foot and the Extensor Brevis Digitorum, but by a second fibrous layer lying upon the tarsus.

Variations.—In five per cent. of cases, according to Gruber, the anterior tibial nerve exhibits an island formation.—It may rarely supply the opposed surfaces of the second and third toes. The branches to the dorsum of the foot are variable: they may interchange with the branches of the external cutaneous and the external saphenous nerves. From the internal branch one, and from the external branch two or three, slender interosseous branches are sent forward over the inter-metatarsal spaces to the metatarso-phalangeal articulations. The second, and sometimes the first of these nerves, give twigs to the dorsal Interosseous muscles on which they lie.[1]

Remarks.—In lead palsy the Tibialis Anticus muscle may escape, while all other muscles supplied by the anterior tibial nerve may be paralyzed.[2] The anterior tibial nerve may be torn across in fracture of the tibia and the fibula.

PERFORATING CUTANEOUS NERVE.

The Perforating Cutaneous Nerve (perforans ligamenti tuberoso-sacri)[3] arises as a small branch, usually from the fourth sacral nerve, but often from the pudic nerve. Piercing the great sacro-sciatic ligament, it turns upward over the lower border of the Gluteus Maximus muscle, and is distributed to the skin over the lower part of the buttock.

THE SYMPATHETIC NERVOUS SYSTEM.

The Sympathetic Nervous System is composed (1) of large numbers of ganglia joined by delicate bundles of nerve-fibres, and (2) of branches which are distributed mainly to the bloodvessel system and to the viscera. The ganglia are arranged in two general systems, of which one consists of two chains of ganglia, united by short cords and placed symmetrically, one on each side of the spinal column; while the other system consists of ganglia and plexuses, which are arranged for the most part about the great blood-vessels of the head, neck, and trunk, and are numerous in the regions of the thorax and abdomen. The gangliated cords are connected with the adjacent anterior primary divisions of the spinal nerves by short branches (roots of the sympathetic system, communicating branches). Two such branches are commonly found for each spinal nerve, though one nerve only is occasionally found.

[1] D. J. Cunningham, Journ. of Anat. and Phys., 1879, xiii. 399.

[1] Ibid., 398.

[2] G. Remak, Archiv f. Psychiatrie u. Nervenkrankheiten, 1876, vi. 1.

[3] Schwalbe, Neurologie, 981.

The ganglia are distributed through the head, neck, and trunk as follows:—

In the head, four.
In the neck, three.
In the dorsal region, twelve.
In the lumbar region, four.
In the sacral region, five.
In the coccygeal region, one.

The branches of the sympathetic nervous system are: those which unite the ganglia, and form, according to some authors, the two main axes or *gangliated cords* of the system; those which communicate with the cranial and the spinal nerves; and those which are distributed to viscera and bloodvessels.

The Sympathetic System will be considered under the following heads:—

The Cephalic Portion.[1]

The Cervical Portion.
- Superior Ganglion.
- Middle Ganglion.
- Inferior Ganglion.
- Cavernous Plexus.
- Carotid Plexus.

The Thoracic Portion.
- Spinal Ganglia.
- Cardiac Plexuses.
- Splanchnic Nerves.

The Abdominal Portion.
- Spinal Ganglia.
- Solar Plexus.
- Phrenic Plexus.
- Hepatic Plexus.
- Gastric Plexus.
- Splenic Plexus.
- Superior Mesenteric Plexus.
- Aortic Plexus.
- Suprarenal Plexus.
- Renal Plexus.
- Spermatic Plexus.
- Inferior Mesenteric Plexus.
- Superior Hypogastric Plex.

The Pelvic Portion.
- Spinal Ganglia.
- Inferior Hypogastric Plex.
- Hemorrhoidal Plexus.
- Vesical Plexus.
- Prostatic and Seminal Plex.
- Cavernous Nerves.
- Vaginal Plexus.
- Uterine Plexus.
- Nerves to Clitoris.

[1] The Cephalic Portion is treated in the main under the head of the fifth cranial nerve.

The Cervical Portion of the Sympathetic System is composed of three ganglia and their branches as follows:—

The Superior Cervical ganglion.
The Middle Cervical ganglion.
The Inferior Cervical ganglion.

The Superior Cervical Ganglion is the largest in the neck. It is usually spindle-shaped and flat, and rests upon the Rectus Capitis Anticus Major, opposite the transverse processes of the second and third cervical vertebræ, and behind the internal carotid artery, and the pneumogastric and hypoglossal nerves. The branches of the ganglion are as follows:—

Superior branch.
Inferior branches.
Anterior branches.
Posterior branches.

The *superior branch*, the most remarkable, appears to be a continuation of the ganglion; and through its distribution upon the internal carotid artery and its branches furnishes these vessels with sympathetic filaments. The main branch soon divides upon the carotid artery, as it lies within the carotid canal, into two branches, the *external* and the *internal*. Through the union of the subdivisions of these branches the *carotid plexus* is formed. As the filaments of the internal division enter the cavernous sinus, they effect a second plexiform combination known as the *cavernous plexus*. Beyond this point the sympathetic filaments are lost upon the terminal branches of the internal carotid artery.

The anastomotic filaments of the above-named branches are exceedingly intricate. Proceeding in their enumeration from below upward, we recognize: 1st. A branch to the *tympanic branch* (Jacobson's nerve). This arises from the external branch, and pierces the carotid canal to enter the tympanic cavity. 2d. A branch to the *spheno-palatine ganglion*. This joins the ganglion through association with the Vidian nerve. 3d. Branches from the carotid plexus to the *sixth nerve*, which are relatively large and important. 4th. Branches from the cavernous plexus to the *third, fourth*, and *fifth nerves*, and to the *ophthalmic ganglion*. These are of extreme delicacy and subject to irregularity in distribution. A branch is also described extending to the Casserian ganglion.

The *inferior branches*. The lower border of the superior cervical ganglion is often bifid, and gives origin to two nerves. One of these is the main associated nerve of the sympathetic, and joins the succeeding sympathetic ganglion. The other is the *superior cardiac nerve*, which arises by one or two

roots from the inner aspect of the lower extremity of the ganglion. It passes downward and slightly inward, in front of the Longus Colli muscle and behind the inferior thyroid[1] and the common carotid artery. At the lower part of the neck the nerve is parallel to the recurrent laryngeal nerve, and enters the thorax behind (sometimes in front of) the subclavian artery, to join the deep cardiac plexus. It furnishes in addition branches of union with the superior laryngeal and recurrent laryngeal nerves, as well as with the superior cardiac branch of the pneumogastric nerve. The nerve is very variable, and may be absent on the right side.

The *anterior branches.* These embrace (1) the *nerves anastomosing with the pharyngeal plexus*, which join the plexus to its outer side, opposite the Middle Constrictor muscle; and (2) the *nerves to the fibres* which form the branches upon the external carotid artery, and which join the inter-carotid ganglion.

The *posterior branches.* These include (1) *branches of union with the spinal nerves;* these join the first, second, third, and fourth nerves, and pass from the ganglion downward and backward at its outer side: and (2) the *nerves anastomosing with the ninth, tenth, eleventh, and twelfth cranial nerves.* Twigs of communication pass to both the ganglia of the glossopharyngeal and pneumogastric nerves, and to the trunk of the hypoglossal nerve.

The superior cervical ganglion may be more or less adherent to the sheaths of the pneumogastric and hypoglossal nerves. Cruveilhier mentions an instance in which the pneumogastric was closely adherent to the ganglion over its entire length. It may send branches to the prevertebral muscles and to the ligaments of the upper cervical region. According to Cunningham,[2] there is no branch of connection between the superior ganglion and the spinal accessory nerve.

The Middle Cervical Ganglion, smaller and less constant than either the superior or inferior, is an irregular mass situated upon the inferior thyroid artery at its origin. It communicates with the ganglia above and below it by well-defined cords. It sends branches to the fifth and sixth cervical nerves; to the inferior thyroid artery; and through the *middle cardiac* nerve (great cardiac nerve) to the cardiac plexus. This nerve runs downward behind the internal carotid artery, and enters the thorax either in front of or behind the subclavian artery, to the arch of the aorta and to the heart. It is, however, of variable size, and often anastomoses with the superior and inferior cardiac nerves.

Branches of this ganglion may join the phrenic nerve and may supply the coats of the transversalis colli artery.

The Inferior Cervical Ganglion lies in advance of the transverse process of the seventh cervical vertebra above the articulation of the head of the first rib with the body of the first dorsal vertebra, behind the subclavian artery and near the origin of the vertebral artery. It is irregular in shape, but is often of a flattened semilunar form with its concavity directed upward As a rule it is connected by a short flat cord with the first thoracic ganglion, lying a little below and externally. In other instances the two ganglia are merged.

The branches of the inferior cervical ganglion embrace the following: The *inferior cardiac* nerve. This varies slightly in its course on the two sides. On the left it descends behind the aortic arch to the posterior cardiac plexus, while on the right it lies behind the innominate artery. It is often intimately associated with the middle cardiac nerve, and with the recurrent laryngeal nerve. *Arterial branches*, which ascend with the vertebral artery, and anastomose with the spinal nerves as far as the fourth.

The thyroid gland receives minute fibres from the filaments about the superior and inferior thyroid arteries.

THE THORACIC PORTION OF THE SYMPATHETIC NERVE.

This consists of two portions, the spinal ganglia, and the visceral plexuses or ganglia.

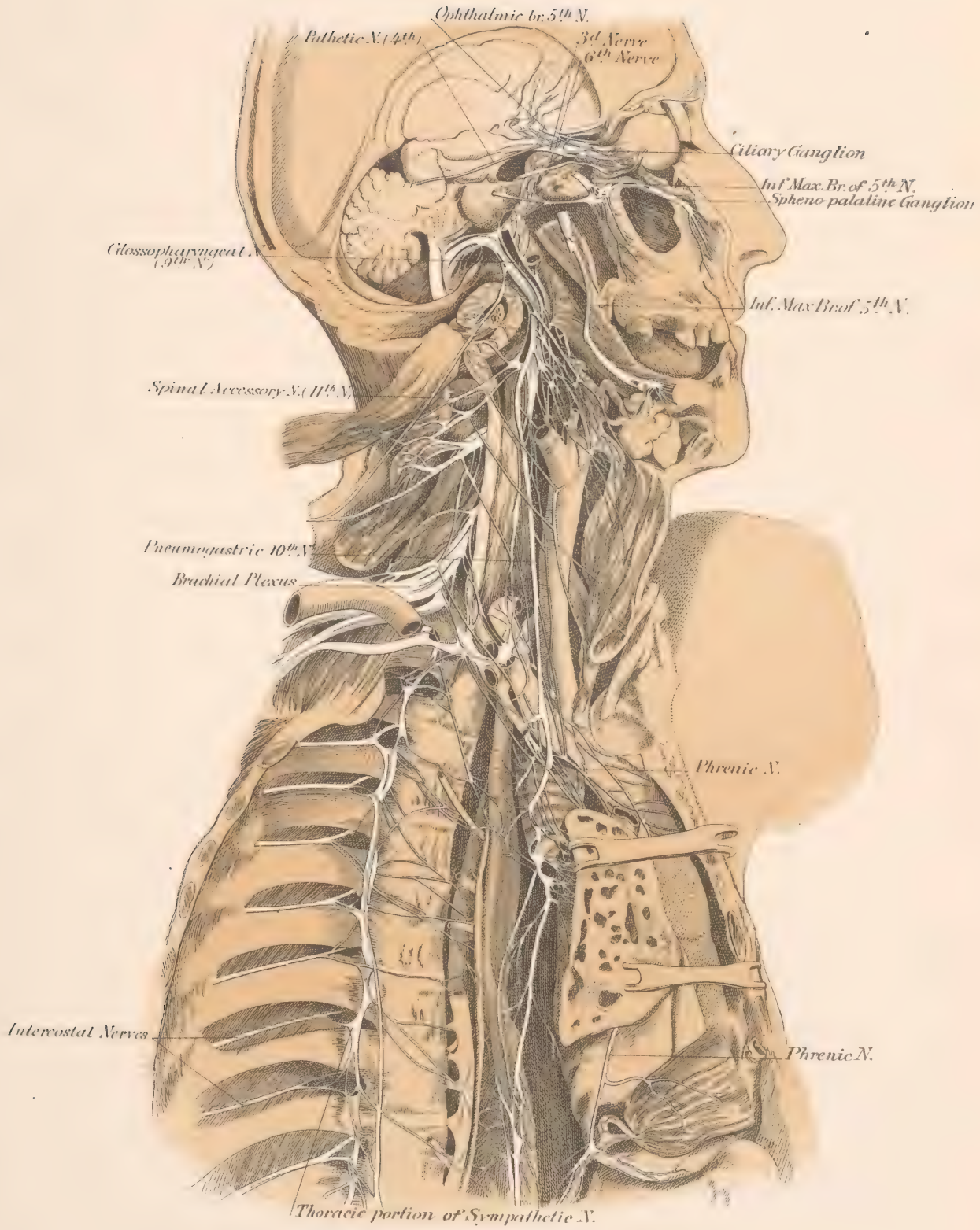
The spinal ganglia in the thorax are placed along the sides of the spinal column, and are twelve in number; occasionally this number is reduced by the coalescence of two or three of the ganglia. Each is

[1] According to Quain, it passes in front of the inferior thyroid artery.

[2] Journ. of Anat. and Phys., 1873, 94.

EXPLANATION OF PLATE XCI.

A dissection exhibiting specially branches of the fifth nerve, the pneumogastric nerve, the spinal accessory nerve, and the spinal nerves as they form the cervical, brachial, and intercostal divisions.



T. Sinclair & Son, Lith.

of an irregularly triangular form, and is placed upon the head of its own rib, beneath the costal pleura, and over the intercostal arteries. Each ganglion communicates with the nerves of the spinal cord (viz., the intercostals) by two branches. One of these, it is thought, is a branch of the intercostal; the other is a branch from the ganglion.

The branches of the thoracic sympathetic are in the main designed for the bloodvessels of the thorax, and of a portion of the abdomen. A few nerves supply the descending aorta, in association with some of the cardiac branches, and pass with this vessel to the abdomen; others supply the vertebræ and ligaments, the azygos vein, the intercostal vessels; and others yet join the posterior pulmonary plexus. The majority, however, effect combinations with plexuses. The nerves from the first to the sixth dorsal are contributory to the *cardiac plexuses*, and those from the fifth to the twelfth form the three *splanchnic nerves*. The thoracic aorta is surrounded by a plexiform arrangement of fibres.

THE CARDIAC PLEXUSES.

The sympathetic fibres descend from the second to the fifth dorsal ganglia, and unite with the cardiac branches of both pneumogastric nerves, and with the first, second, and third cardiac branches of the cervical portion of the sympathetic, to form the cardiac plexuses. These plexuses extend from the upper border of the arch of the aorta to the base of the heart, and surround the ascending aorta and the trunk of the pulmonary artery.

The cardiac plexuses are two in number—

The Anterior Cardiac Plexus.
The Posterior Cardiac Plexus.

The Anterior Cardiac Plexus (superficial cardiac plexus) is the smaller of the two, and is situated at the anterior and under surface of the arch of the aorta, to the right side of the infundibulum. The plexus often possesses two ganglia at the bifurcation of the pulmonary artery, of which the right, called the *ganglion of Wrisberg*, is the larger.

The plexus receives the left superior cardiac nerve and the cardiac branches of the left pneumogastric nerve, and, by means of the anterior coronary plexus, sends branches to the anterior portion of the heart.

The Posterior Cardiac Plexus (deep cardiac plexus), the larger and thicker of the two plexuses, lies behind the arch of the aorta and in front of the point of the bifurcation of the trachea. It receives the middle and inferior cardiac nerves, and is distributed in part through the posterior coronary plexus, and through its numerous auricular branches to the posterior surface of the heart.

Each cardiac plexus forms at the base of the aorta, and at the origin of the anterior and posterior coronary arteries, a secondary plexus. These constitute the *coronary plexuses*, and their branches are distributed along the main lines of the coronary vessels. The *anterior coronary plexus* (right coronary plexus) is a continuation of the superficial cardiac plexus. It embraces the root of the aorta, passes to the right coronary artery by running in the groove between the aorta and the pulmonary artery, and supplies the anterior surface of the heart. The *posterior coronary plexus* (left coronary plexus) is larger than the anterior. It arises for the most part from the left portion of the posterior cardiac plexus, and passes behind the pulmonary artery to the left coronary artery, along the main branches of which it passes to supply the walls of the ventricles.

According to Pettigrew, the cardiac nerves describe a spiral course, and are arranged in lines opposed to the spiral direction of the muscular fibres. The arrangement of the nerves beyond this is to a slight degree plexiform, the minute plexuses being associated with branches of the arteries which they cross. The *Ganglia of Remak* are minute ganglia found upon the nerves in the substance of the heart.

THE SPLANCHNIC NERVES.

The Splanchnic Nerves are branches derived for the most part from the spinal system of nerves, and are whiter and firmer than are the other nerves included within the sympathetic. The majority of the roots composing the nerves can be traced either to the communicating root with the intercostal nerves, or to the branch lying between the thoracic ganglia.

The splanchnic nerves are two in number, the *greater* and the *lesser*.

The Great Splanchnic Nerve arises from the fifth to the tenth, or from the sixth to the ninth thoracic ganglia. It lies nearly parallel to the vertebral column above, but inclines slightly downward and inward, and becomes flattened below. The nerve becomes flattened near the base of the thorax, escapes by piercing the Diaphragm at its crus, and ends in the semilunar ganglia. Just prior to its exit from the thorax, it exhibits on the right side an oval ganglion called from its position the *ganglion splanchnicum*. A similar ganglion is inconstantly present on the left side.

The Lesser Splanchnic Nerve arises from the tenth and eleventh thoracic ganglia. It is inconstant in its relations, and, though usually joined to the great

splanchnic, it may be distinct from it, or be duplicated in its general direction by another nerve arising from the twelfth ganglion, which has received the name of the *third splanchnic* (smallest splanchnic, renal splanchnic). The lesser splanchnic nerve may effect its exit from the Diaphragm through the same opening as the greater splanchnic, but more frequently it lies further to the outer side, and escapes by a minute orifice beneath an arciform tendon to join the cœliac plexus.

When the third splanchnic nerve is present, it either joins the same plexus with the foregoing, or passes behind the kidney to the renal plexus. Hence it has received the additional name of the *renal splanchnic nerve.*

The great splanchnic nerve may be traced to the fourth and the fifth dorsal ganglia, and, according to T. S. Beck,[1] as far as the first dorsal ganglion.

THE ABDOMINAL PORTION OF THE SYMPATHETIC SYSTEM.

The plexuses of the abdomen are—

The Solar.	The Phrenic.
	The Hepatic.
	The Gastric.
	The Splenic.
	The Aortic.
	The Superior Mesenteric.
	The Suprarenal.
	The Renal.
	The Spermatic.
	The Inferior Mesenteric.
	The Superior Hypogastric.

Of these the hepatic, gastric, splenic, aortic, and superior and inferior mesenteric are asymmetrical; while the phrenic, suprarenal, renal, and spermatic are symmetrical. The general position of each of these is indicated by its name, and they are all connected with a large central plexus, which is denominated *solar*. These plexuses are composed of associations of ganglia, which, however, have not received distinct names, save in one instance. The manner of combination of the filaments of nerves extending between the plexuses is subject to so much variation that no description of it has been attempted. It will be remembered that the plexuses of the sympathetic invariably follow the course of the larger arteries.

[1] Philosoph. Trans. 1846, 213.

THE SOLAR PLEXUS.

The Solar Plexus (epigastric plexus) is situated upon the aorta, beneath and in front of the aortic opening of the Diaphragm, and surrounds the cœliac axis and the superior mesenteric artery at its origin. It is the largest plexus of the sympathetic system, and from it branches are furnished to all the viscera in the abdominal cavity. It is usually described as composed of a pair of symmetrical masses, called the *semilunar ganglia*, although their shape varies. The convexities of the semilunar ganglia are directed outward, and the concavities inward, where they often join. The left lies nearer the median line than the right, and is partially supported by the aorta; the right lies upon the corresponding crus of the Diaphragm.

According to some writers, that portion of the solar plexus which immediately surrounds the cœliac axis is called the *cœliac plexus;* the hepatic, the gastric, and the splenic plexuses, since they follow the courses of the arteries which arise from the axis, are made subdivisions of the cœliac plexus.

The Phrenic Plexus is placed in the neighborhood of the supra-renal capsules; the nerves composing it being largest on the right side. Its branches accompany the inferior phrenic arteries, and send filaments to the under surface of the Diaphragm. On the right side a small ganglion (ganglion phrenicum) is found.

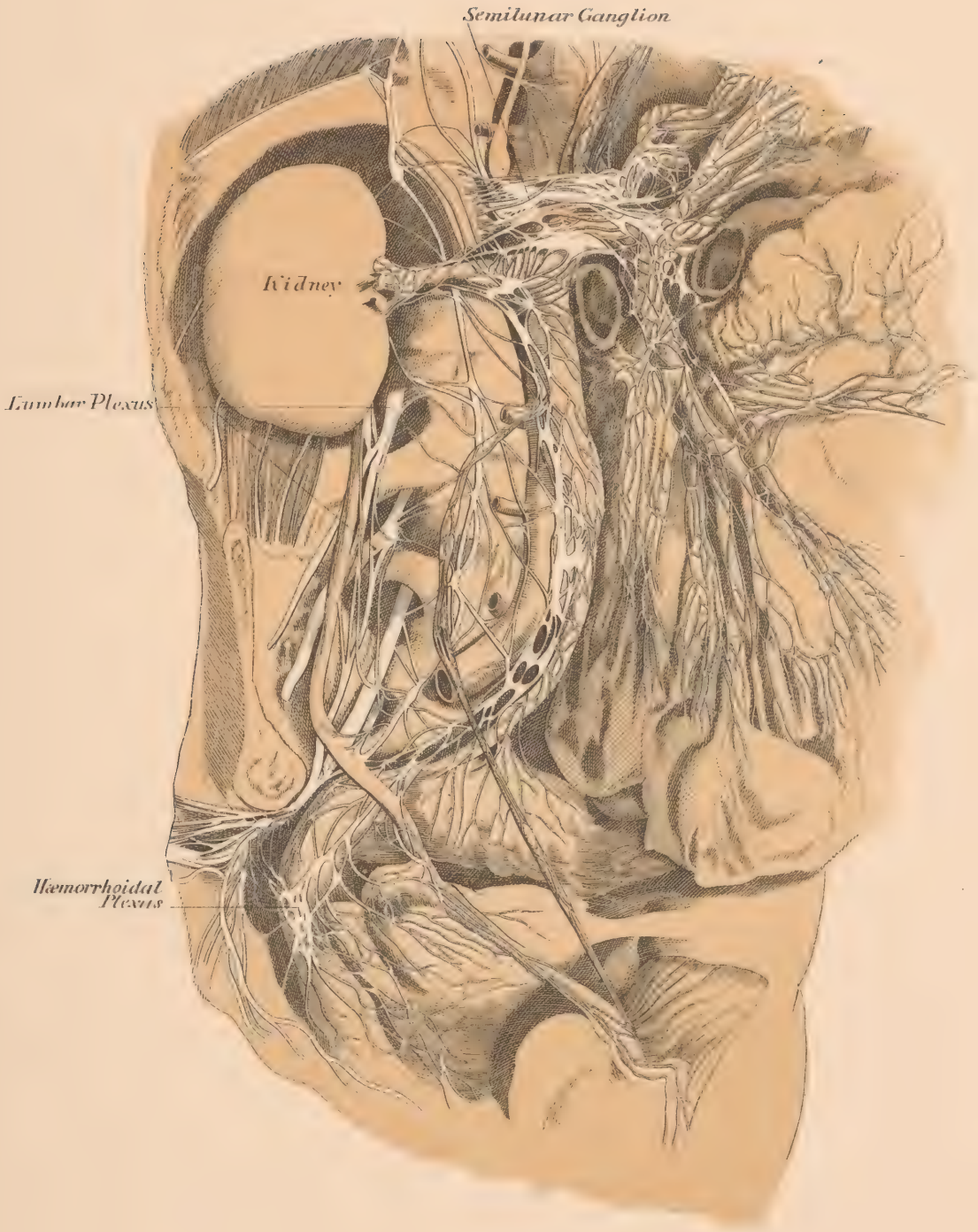
The Hepatic is a large plexus, which may be described as a division of the semilunar ganglia, and is thought to receive accessions from the pneumogastric nerves, particularly from the nerve of the right side. It surrounds the hepatic artery, and supplies the walls of the branches of this vessel, as well as those of the portal vein, the biliary duct, and gall-bladder.

The Gastric Plexus (plexus coronarius ventriculi, plexus stomachicus) accompanies the left coronary artery and joins with the gastric plexiform fibres of the pneumogastric nerves, as well as with branches of the hepatic plexus.

The Splenic Plexus is composed of a division of the left semilunar ganglion and the fibres of the right

EXPLANATION OF PLATE XCII.

A dissection exhibiting specially the sympathetic system of the abdomen and the composition of the lumbar cords.



T. Sinclair & Son, Lith.

pneumogastric nerve. It surrounds the splenic artery and accompanies its branches. The spleen is supplied by it, and in part the pancreas and the cardiac extremity of the stomach.

The Aortic Plexus consists of two nearly symmetrical parts, which are placed for the most part at the sides of the abdominal aorta, between the cœliac and the inferior mesenteric plexus. It communicates with the lumbar portion of the system, particularly the right, and supplies the inferior vena cava. From it arises the inferior mesenteric, and in part the spermatic and the hypogastric plexuses.

The Superior Mesenteric Plexus, in addition to following the artery of that name (so that the nerves emanating from this plexus may be said to supply the small intestine, and the ascending and transverse colons), also sends branches to the spaces between the reticulations formed by the terminal branches of the artery, and is lost in the so-called *external* and *internal mesenteric* plexuses.

The Suprarenal Plexus is formed by branches from the semilunar ganglia of the solar plexus, and from the phrenic plexus. The nerves arising from this plexus pass to the suprarenal bodies, and are remarkable for their large size when compared with that of the structures they supply. One of the splanchnic nerves joins the plexus, and a small ganglion, which is largest on the right side, lies at the point of union.

The Renal Plexus of each side is situated upon the renal artery, and supplies the kidney. It sends branches to the ureter, and occasionally to the ovary.

The Spermatic Plexus on each side is composed for the most part of fibres, which follow the course of the spermatic artery. In the female it supplies the ovary, and terminates at the base of the uterus in the utero-vaginal plexus.

The Inferior Mesenteric Plexus follows the course of the artery of the same name. The branches are distributed to the descending colon, sigmoid flexure, and the upper portion of the rectum. The distribution of the fibres of the plexus is, on the whole, the same as that of the branches of the inferior mesenteric artery.

The Superior Hypogastric Plexus lies in front of the aorta below the origin of the inferior mesenteric artery. It derives accessions from the aortic plexus and from the lumbar portion of the system, and assists in the formation of the inferior hypogastric plexus.

THE LUMBAR PORTION OF THE SYMPATHETIC SYSTEM.

The lumbar portion of the sympathetic system includes those portions of the gangliated cords which extend from the last dorsal vertebra to the sacro-vertebral angle. It preserves the general features elsewhere presented. The ganglia, however, are smaller and more oval than the thoracic ganglia. They lie to the inner side of the Psoas muscle. The communicating branches with the spinal nerves follow the general direction of the lumbar arteries and are long and slender. The visceral branches extend across the vertebral column covered by the fibrous bands from which the Psoas arises, transversely above, somewhat obliquely downward and inward below. Reaching the aortic plexus, the upper branches are here lost, but those below may directly contribute to the formation of the inferior mesenteric plexus.

THE PELVIC PORTION OF THE SYMPATHETIC SYSTEM.

THE INFERIOR HYPOGASTRIC PLEXUS.

The chief feature of the pelvic portion of the sympathetic nerve is the inferior hypogastric plexus.

The Inferior Hypogastric Plexus begins in the interval between the two common iliac arteries, about opposite the promontory of the sacrum, and it is connected by two slender cords with the superior hypogastric plexus, and lies to the median side of the internal iliac arteries. Its branches of distribution are symmetrical, and are confined to the pelvic viscera and the essential parts of the external organs of generation. Efferent branches are received from the sacral nerves, especially the third and fourth; filaments also reach it from the inferior mesenteric plexus, and a minute filament from the sacral ganglia.

The points of accession of nerves have been called plexuses, and have derived their names from the locality in which they are found.

Thus the Hemorrhoidal Plexus is placed on the side of the rectum. Its efferent branches proceed from the back part of the hypogastric plexus.

The Utero-Vaginal Plexus[1] is best seen in the parturient female. It is well developed at the neck of the uterus and upper half of the vagina, but diminishes along the lateral surfaces above, to the basal half of the broad ligament of the uterus.—The Ovarian Nerves are derived chiefly from the renal plexus.—The Vaginal Nerves contain more spinal fibres than do the uterine branches.

The Prostatic and Seminal Plexuses. In the male, plexiform structures analogous to the above are found, but of much smaller size, and confined to the prostate gland, the seminal vesicles, and the vas deferens. Some of the filaments upon the latter duct enter into

[1] Enumerated as two distinct plexuses on page 577.

combination with branches of the spermatic plexus, which, it has already been seen, is largely derived from the renal plexus.

The Cavernous Nerves for the cavernous bodies of the penis and clitoris are extensions from the prostatic plexus in the male, and the utero-vaginal plexus in the female. Since they are best developed in the male, their consideration will be here confined to that sex. The cavernous nerves escape from the pelvis beneath the pubis at the anterior margin of the Levator Ani muscle, receiving some filaments from the perineal branch of the internal pudic. They divide into branches which enter the cavernous body of the corresponding side, and are lost in that structure, joining some terminal twigs of the dorsal nerve of the penis, and sending a few filaments to the spongy body.

The Vesical Plexus is rich in spinal nerves. It is best developed at the base of the bladder.

The inferior hypogastric plexus in addition supplies the inferior part of the ureters.

THE SACRAL PORTION.

The Sacral Portion of the sympathetic nerve presents from three to five ganglia placed to the inner side of the sacral foramina. The ganglia decrease in size from above downward, and bear in their general relations a likeness to ganglia elsewhere. The ganglia and their connecting nerves of either side slightly converge as they descend, and the last sacral ganglia are often united by a delicate loop.

As a rule, a central ganglion—*ganglion impar*—is lodged upon the first coccygeal vertebra, and is in close connection with the loop above mentioned.

The sacral sympathetic sends branches directly inward, uniting with one another to form a plexiform arrangement along the middle sacral artery. Others join the inferior hemorrhoidal nerve below, to supply the lower end of the rectum, where they may join the coccygeal nerve. From the loop below the last sacral ganglia nerves are distributed to the coccyx, to the adjacent ligamentous structures, and to the coccygeal body. Filaments from the *ganglion impar* often supply the periosteum of the coccyx and the sacro-sciatic ligament.

Remarks.—While it is recognized that the sympathetic system is one of great importance in the economy, and the results of experiment on the lower animals show that its nerves are composed of motor, sensory, vaso-motor, inhibitory, and trophic fibres, the examples are but few in number in which any application of a knowledge of the nerves composing it has been made to clinical medicine.

D. Cunningham[1] found that the size of the splanchnic nerve was greatly increased in hypertrophy of the abdominal viscera.—Congestion of the solar plexus, either as a result of blows on the abdomen, or from idiopathic causes, has often been found associated with excessive diarrhœa. W. Sedgwick[2] connects these phenomena with the etiology of cholera, while J. W. Ogle[3] traces the occurrence of diarrhœa in a patient, the subject of aneurism of the superior mesenteric artery, to a similar cause.

J. F. Lobstein[4] records an instance of inflammation of the semilunar ganglia in a case of a woman, aged forty-two, who died from the effects of the vomiting of pregnancy.

The connection between injuries of the cervical or of the brachial plexus and the condition of the pupil has long been known. The following cases may be given in illustration of this condition. Seeligmüller[5] found, in association with total paralysis of the brachial plexus, dilatation of the pupil of the corresponding side. J. H. Hutchinson[6] relates a case of injury to the brachial plexus, which was associated with irregular action of the pupil and recession of the eyeball of the corresponding side.

In the course of the removal of a sarcoma, of the size of a small orange, from the upper portion of the right anterior triangle of the neck, by Chavasse, it became necessary to dissect away the trunks of the pneumogastric and cervical nerves, to which the tumor had become adherent. At the conclusion of the operation the pupil of the right eye was seen to be contracted to the size of a pin's head. Three days later the pupil was still irregularly contracted, as at the conclusion of the operation, but acted under the stimulus of a strong light. There was also drooping of the palpebral fissure. There had been frequent and distressing vomiting. A few days later a few drops of atropine were placed in the affected eye, but the pupil dilated very slowly under its action. Two months after the operation, the pupil was still contracted irregularly and responded but slowly to changes of light.

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[1] Journ. of Path. Anat. and Phys., 1879, 508; also Ibid., 1878, 294.

[2] Med.-Chir. Trans., 1868, l. 1; see, also, Moreau, Comptes Rendus, lxvi.

[3] Trans. Path. Soc. Lond., 1857, viii. 168.

[4] Structure of the Sympathetic Nerve, Amer. Trans., 1831, 133.

[5] Centralblatt f. Medicin. Wissen., 1878, 12; also Archiv für Klin. Med.

[6] Trans. Path. Soc. Lond., 1881, 27.

Under the name of *ganglion cervicale uteri*, Frankenhäuser[1] describes a distinct ganglion furnishing nerves to the neck of the uterus, which is in great part distinct from the nerves of the uterus. According to N. W. Jastreboff,[2] from results based upon the dissection of thirty subjects, a plexus exists in the place of this so-called ganglion. Into it branches of the sacral nerve can be traced. The same writer finds many functional diseases of the uterus most probably dependent upon diseased action localized in the plexus. In a case of polypoid growth, situated at a portion of the attachment of the placenta, interstitial inflammation and fatty degeneration were detected in the cells of the anterior portion of the plexus. In a second case, where death ensued upon eclampsia, fatty degeneration of the cells existed in the anterior portion of the plexus. Similar effects were observed in a case of cirrhosis of the liver, accompanied by fibro-myoma of the ovaries and ascites, and in a case of carcinoma of the right ovary.

Mitchell, Morehouse, and Keen[3] describe a case of gunshot wound of the right side of the neck, which was thought to involve the cervical portion of the sympathetic system. The pupil of the eye of the corresponding side was contracted, the eyelid fell, the outer angle of the palpebral fissure drooped, and a disposition to lachrymation existed. Occasional flushings of the right side of the face were complained of.

W. Ogle[1] affirms that injuries of the neck may induce symptoms comparable to those secured by experiment upon the cervical sympathetic nerves of the lower animal. An abscess on the right side of the neck had apparently caused destruction of the right cervical portion of the sympathetic system, and was followed by flushings of the right ear and of the right side of the face and elevation of temperature, narrowing of the right palpebral fissure, retraction of the corresponding eyeball, and contraction of the right pupil.

J. M. Da Costa and M. Longstreth[2] find that in Bright's disease, particularly in cases of contracting kidney, there exists a constant lesion of the renal plexus. The cells are granular, the connective tissue proliferating, and the disposition to fatty degeneration manifest. In visceral syphilis, P. Petnow[3] has determined analogous morbid changes to take place.

---

[1] Die Nerven der Gebärmutter.

[2] Trans. of the Obstet. Soc. Lond., 1882, xxiii. 266.

[3] Gunshot Wounds and other Injuries of Nerves, 39; also Injuries of Nerves, loc. cit., 319.

[1] Med.-Chir. Trans., 1869, iii. 153; see, also, J. W. Ogle, Ibid., 1858, xli. 397.

[2] Amer. Journ. of the Med. Sci., 1880, n. s. clix. 17.

[3] Virchow's Archiv, 1873, lvii. 121, figs.

ALLEN'S

HUMAN ANATOMY.

ORGANS OF SENSE,

ETC.

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ERRATA.

On page 593, first columm, third line from top, *insert* the words "in part" *after* the word "muscles." On same page, second column, sixth line from top, *for* "phthisis bulbo" *read* "phthisis bulbi." On same column, twenty-sixth line from the top, *omit* the word "artery" *after* the word "ciliary."

On page 597, first column, twentieth line from the bottom, *insert* the word 'visual" *before* the word "axis."

On page 598, first column, first line, *insert* the word "until" *before* the word "recently." On same page, same column, *for* "into" *read* "toward." On same page, same column, *in advance* of word "pulsate" *insert* the word "sometimes."

On page 599, first column, fourteenth line, *for* "capsule" *read* "suspensory ligament;" and on same page, same column, sixteenth line, *in advance* of the words "the vitreous body" *insert* the words " hyaloid membrane of."

On page 599, second column, eleventh line from top, *between* the words "suspensory ligament" and "the posterior capsule and the lens" *insert* the words " the fibres to."

On page 631, in description of Fig. 160, *for* "back" *read* "side."

On page 760, first column, twelfth line from top, *for* "749" *read* "750."

On page 760, second column, sixth line from bottom, *for* "ducts" *read* "educts."

On page 764, first column, seventh line from the bottom, *for* "male" *read* "mole."

On page 776, first column, eleventh line from bottom, *for* "If the centre of attraction is the" *read* "If the centre of attraction of the."

ORGANS OF SENSE.

THE EYE.

The Eye is described as composed of the *eyeball*, or the organ of vision, and its *appendages*. It is convenient to describe the appendages of the eye before the eyeball itself.

The Appendages of the Eye.

The Appendages of the Eye are—

I.
- The Eyelids.
- The Conjunctiva.
- The Eyebrows.
- The Capsule of Tenon.
- The Periocular muscles.

II. The Lachrymal Apparatus.

I. The eyelids and conjunctiva, and the eyebrows.

THE EYELIDS AND CONJUNCTIVA.

The Eyelids. The *eyelids* are special structures, composed principally of skin, conjunctiva, and interposed muscle and so-called cartilage, and are designed to cover the front of the eye, as in the act of winking and in sleeping.

Under the head of the eyelids may be considered the following subjects:—

The Skin.
The Palpebral Fissure.
The Palpebral Ligaments.
The Tarsal Cartilages.
The Meibomian Glands.
The Eyelashes.
The Muscles.

The Skin of the Eyelids is thin, nearly translucent, and without subcutaneous fat. The skin of the upper lid is derived from the brow, that of the lower lid from the cheek. The inner surfaces of the eyelids are in contact with the palpebral conjunctiva. The eyelids secure their form, and in great measure their efficiency, through the tarsal cartilages.

The Palpebral Fissure. The space between the eyelids is called the palpebral fissure. It is an elliptical opening, varying in size in different individuals, and in the same individual at different times as in the changes of expression.—The angles of the fissure are called the *canthi*. The *outer canthus* (external angle) is acute, and defined by the tarsal cartilage; the *inner canthus* (internal angle) is rounded and prolonged as a horizontal *cul de-sac* beyond the lachrymal puncta. The free edges of the eyelids form the upper and lower borders of the palpebral fissure, are flat, and come directly in contact in winking; they are furnished in front with eyelashes. The opposed borders of the inner canthus alone are rounded and nearly hairless.

The Palpebral Ligament. The form of the eyelid is determined by the palpebral ligament (septum orbitale). This is a fibrous expansion continuous with the borders of the orbit. It is greatly strengthened toward the free edges of the palpebral fissure by the *tarsal cartilages* (palpebral cartilage), which, although so separately denominated, are only differentiated portions of the palpebral ligament, being dense fibrous tissue with some admixture of elastic tissue. Each "cartilage" is thick at its free border, but thin at the upper. The *upper tarsal cartilage* is the larger, of crescentic shape, and measures nine lines long, and four lines wide in the centre. The *lower tarsal cartilage* is nearly fusiform, or is ribbon shaped.

The palpebral ligament lies as a compact layer two lines in length between the outer canthus and

the orbit, where it has received the name of the *external canthal ligament* (external palpebral ligament), and is continuous with the tarsal cartilage. Towards the inner angle of the palpebral fissure, it strengthens the opposed border of the canthus, and is continuous with the tendon of the Orbicularis Palpebrarum muscle.

The Meibomian glands (palpebral glands). The posterior surfaces of the tarsal cartilages are grooved for the reception of numerous glands, which open upon the margins of the eyelids. They vary in number from twenty-five to thirty in the lower lid, and from thirty-five to forty in the upper. Each gland is composed of imperfectly defined lobules attached to a single straight duct. The secretion of the Meibomian glands is sebaceous in character, and serves to lubricate the edges of the lids, and to prevent the lachrymal secretion from flowing out upon the face.

The Eyelashes. The edges of the palpebral fissure are furnished with numerous curved hairs, forming the eyelashes. They are arranged in two or three irregularly wavy rows; the upper set curve downward and forward, the lower set upward and forward.

The Muscles. The muscles of the eyelids are three in number, namely: (1) The palpebral fibres of the Orbicularis Palpebrarum, which are arranged in a thin layer parallel to the line of greatest length of the eyelids. (2) The Orbito-Palpebral fibres (H. Müller and Sappey), which are situated deeper than the preceding, and are arranged at right angles, *i. e.*, vertically to the foregoing. (3) The fibres of termination of the Levator Palpebræ muscle, which, by their insertion into the palpebral ligament, and association with the orbito-palpebral fibres, may be here included.

The Conjunctiva. The *conjunctival chamber* is the space between the eyelids and the eyeball. It is lined with a mucous membrane, *the conjunctiva*, and receives the secretion of the *lachrymal* and *conjunctival glands*. The conjunctiva is continuous with the nasal mucous membrane through the lachrymo-nasal ducts. It is composed of two portions, a palpebral and an ocular.

The *palpebral layer* is in close connection with the eyelids. It is thinner and more vascular than the ocular layer. The vessels are derived from the superior and inferior ophthalmic arteries.

The *ocular layer* consists of a scleral portion and a corneal reflection of its epithelium. The *scleral portion* is freely movable upon the eyeball—a feature due to the necessity of motion between the eyeball and the orbit. The vessels are derived from the lachrymal branches of the ophthalmic, and anastomose with those of the ciliary arteries. The nerves are derived from the ophthalmic division of the fifth nerve. At the junction of the scleral portion with the cornea, a crescentic fold called the *limbus conjunctivæ*, is seen in the aged, which measures half a line in thickness. The *corneal reflection* is very thin and transparent. It is closely adherent to the cornea, and in health is without bloodvessels.

The portion between the palpebral and ocular layers presents some features of interest, being near the bases of both lids, and termed the *fornix conjunctivæ*. The conjunctiva is here loosely attached, and is rich in minute racemose glands. Toward the palpebral portion, namely, at the termination of the tarsal cartilage, are numerous papillæ (conjunctival papillæ), best marked in the upper eyelid, which are engorged in catarrhal conditions.—The union between the two layers at the inner canthus marks the *lachrymal caruncle*. This structure occupies the position of the internal canthus, and is slightly movable by traction of the eyelids, yet it is concealed by their closure; it is composed for the most part of sebaceous glands, and is furnished with a few small white hairs. To the outer side of the caruncle is a vertical fold of the conjunctiva, *the plica semilunaris;* this fold apparently belongs to the scleral portion, but is believed to be the rudiment of the nictitating membrane of lower animals, under which term is included a supplementary eyelid acting from within outward. It contains a small quantity of unstriped muscular fibres.

Minute Anatomy. The conjunctiva is composed of three layers: the stratified pavement epithelium, the basement membrane upon which the former rests, and the connective-tissue matrix of the mucous membrane proper, arranged after the manner found on other mucous surfaces. Upon the cornea the first two layers alone are seen. It is the rapid disappearance of the epithelium that causes the duskiness of the cornea to be so soon apparent after death.

Under the head of the *oculo-palpebral groove* may be described a space between the eyeball and the eyelid. It is six or seven lines in depth in the upper eyelid, and four lines in depth in the lower.

Remarks.—An instrument penetrating the eyelids at a point beyond the limits of the oculo-palpebral groove, would not involve the conjunctiva.[1] Malgaigne fixes this limit for the upper eyelid at seven or eight lines from the edge of the lid, and for the

[1] Richet, Anat. Chirurg., 1860, 314.

lower eyelid at three-quarters of a line.—Emphysema of the lids may occur from fracture of the ethmoidal plate. A blow upon the face at the region of the eye will, as a rule, not involve the eye itself, but will be received upon the malar bone and the supra-orbital ridge. Thus an ecchymosis from this cause will be more apt to be located in the integuments about the eye than in the conjunctival or subconjunctival surfaces. The lower eyelid sags in facial palsy.

THE EYEBROWS.

The Eyebrows are curved lines defined by numbers of stout hairs situated between the regions of the forehead and of the eyes, and nearly corresponding to the supraorbital arches.[1]

The eyebrow is divided into two parts by the directions of the hairs composing it. The hairs of the median third of each brow tend to arrange themselves in vertical or oblique lines, and may merge with those of the eyebrow of the opposite side. The hairs of the remaining two-thirds are nearly horizontal, and become less compactly disposed near the temple. Occasionally one or the other of these divisions may be absent. The median division would appear to answer to the pilose wart commonly present in quadrupeds, which is determined by the presence of terminal trophic filaments of the supraorbital nerve.

The eyebrows serve to deflect the perspiration of the brow from the eyes, and to act, when shaggy, as a shade to the eye when the light falls from above.

II. The lachrymal apparatus.

The Lachrymal Apparatus (figs. 2 and 3, Plate XCVI.) consists of—

The Lachrymal Gland.
The Canaliculi.
The Lachrymal Sac.
The Lachrymo-Nasal Duct.

The Lachrymal Gland is an almond-shaped body half an inch broad and three-quarters of an inch long, situated within the orbit towards its outer side. It is lodged within the lachrymal fossa of the frontal bone, and is protected in part by the external lateral process. It is obscurely lobulated, is of a pale reddish color, and presents a convex surface above, and a concave one beneath. It is fixed to the periosteum of the orbit by a few tendinous fibres, and is a racemose gland, closely resembling the true salivary gland, and for the most part inclosed within a thin capsule. The lachrymal gland is divided into two portions, the superior and the inferior. The *superior portion* is much the larger and the more compact of the two. The *inferior portion* is lodged in the subconjunctival connective-tissue at the superior fornix conjunctivæ. The ducts of the lachrymal glands are from ten to twelve in number, and open into the superior palpebral sinus at its outer third, and at a point about one-fourth of an inch above the tarsal cartilage. A few minute glands belonging to the lower division may open at or below the external angle.

The *arteries* of the lachrymal gland are derived from the ophthalmic artery. The *nerves* arise from the ophthalmic branch of the fifth nerve.—Both vessels and nerves enter the glands from below and behind.

The Canaliculi are little canals running from the edges of the eyelids to the lachrymal sac. They are two in number, one for either lid. Each begins in the centre of the lachrymal papilla by a minute orifice, the *punctum lachrymale*, which is directed toward the eyeball. From this point the canaliculus abruptly widening descends at first and then passes forward and inward. The entire length of each canaliculus is about five lines, and its width two lines. The two canaliculi converge towards the lachrymal sac. The lower is somewhat the larger, and is placed nearly horizontally. As a rule they open separately between one and two lines below the summit of the sac, on the orbital side.

Each canaliculus is lined by a pavement epithelium resting upon an abundant connective-tissue stroma, the whole being inclosed by the longitudinal fibres of the Orbicularis Palpebrarum muscle and the skin. The palpebral ligament gives strength to the outer wall of each canaliculus, and passes inward to form the internal palpebral ligament.

The Lachrymal Sac is the expanded upper half of the lachrymo-nasal passage. It receives the canaliculi, and is continuous with the lachrymo-nasal duct below. It is of an oval shape, slightly widened above, and is lodged in the sulcus (lachrymal groove) between the crest of the lachrymal bone and the nasal process of the superior maxilla, just behind the insertion of the internal palpebral ligament. It measures six lines in length by about ten in width, but is narrower below. The lachrymal sac is straight along its inner border where it is in connection with

[1] Some writers define the eyebrows as composed, not only of the supraorbital hairs, but of skin, fat, subcutaneous tissue, and muscle-fibres. The term *region of the eyebrow* may be reserved for this locality.

the boundaries of the sulcus, and is held in position elsewhere by an extension of the orbital periosteum, as well as by a slip prolonged inward from the internal palpebral ligament, which is strengthened by Horner's muscle. The main portion of the palpebral ligament crosses it in front, where, according to Luschka, some of the oblique facial fibres of the Orbicularis Palpebrarum arise.

Fig. 126.



The conjunctival space, showing position of lachrymal gland, canaliculi, and lachrymal sac. 1, lachrymal gland; 2, lachrymal sac; * inferior canaliculus.

The Lachrymo-nasal Duct extends from the lachrymal sac to the nose. It measures seven lines in length, being slightly narrower in the middle than elsewhere. Circular at its beginning, it is slightly compressed laterally below. Being directed downward and slightly outward, it terminates at the roof of the inferior meatus. It is throughout adherent to the bony walls of the ductus ad nasum (*q. v.*), and is lined with a ciliated form of epithelium.

Several folds of a valve-like character have been described in connection with the lachrymal apparatus; one is situated just within each lachrymal punctum; one at the orifice of the canaliculi in the lachrymal sac; others within the lachrymal nasal duct, and, finally, one at its nasal outlet.

Remarks.—The mechanism of the flow of tears appears to be as follows: The act of winking forces the tears into the palpebral chamber. The tears suffuse the conjunctiva, and afterwards collect between the margins of the eyelids and the eyeball, where, as a glistening layer, they can always be seen before they fall. The puncta collect this fluid and conduct it by capillary attraction into the canaliculi, and thence into the lachrymal sac; while from that point it descends by gravitation along the lachrymo-nasal duct into the nose. This process, apparently so simple, is complicated by the fact that the abundant muscular tissue about the canaliculi contracts their lumen and prevents, except at the moment of the closure of the eyelids, the relaxation sufficient to permit the outflow of tears.

THE CAPSULE OF TENON.

The Capsule of Tenon (ocular fascia, orbito-ocular aponeurosis, albugineal membrane, tunica vaginalis bulbi) is the name given to the fascia between the walls of the orbit and the eyeball. Its outer surface is distinguished by a number of trabecular bands, which either end in the lobules of periocular fat, or secure attachment to the walls of the orbit. The inner surface is smooth. The fascia is continuous posteriorly with the dura mater, through the sphenoidal fissure and the optic foramen, and anteriorly it is lost upon the subconjunctival connective tissue. The inner aspect of the capsule is lined with epithelial cells, and incloses a lymph-space. The posterior half is much stouter than the anterior half, and the capsule has been compared to a socket, within which the eyeball moves. The anterior half is thin and loosely connected with the eyeball. Posteriorly, the capsule is perforated by the optic nerve and the ciliary nerves and vessels, and anteriorly, by the periocular muscles.

The relation of the fascia to these muscles and adjacent parts is as follows: The external (lateral) portion of the fascia supports the lachrymal gland, and sends off a trabecular band of attachment to the outer wall of the orbit at the malo-frontal suture. The Superior and External Recti muscles give off bands similar to those of the orbital wall posteriorly. The internal (median portion) receives trabecular support from the wall of the orbit posteriorly, near the origins of the Internal Rectus and the Inferior Rectus muscles, and anteriorly at the region of the trochlear process, not only near the insertion of the Superior Oblique, but near that of the Levator Palpebræ and Superior

EXPLANATION OF PLATE XCIII.

Fig. 1. View of the tongue, with attachments to the epiglottis, as seen from above.

Fig. 2. A view of the cartilages of the external nose.

Fig. 3. A semi-diagrammatic view of the sinuses of the dura mater, showing the manner by which venous blood enters the sinus system from within the nasal chamber at the foramen cæcum.

Fig 1



Fig 2

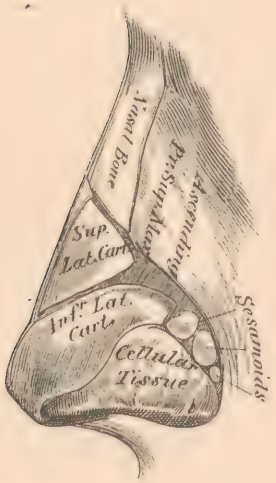
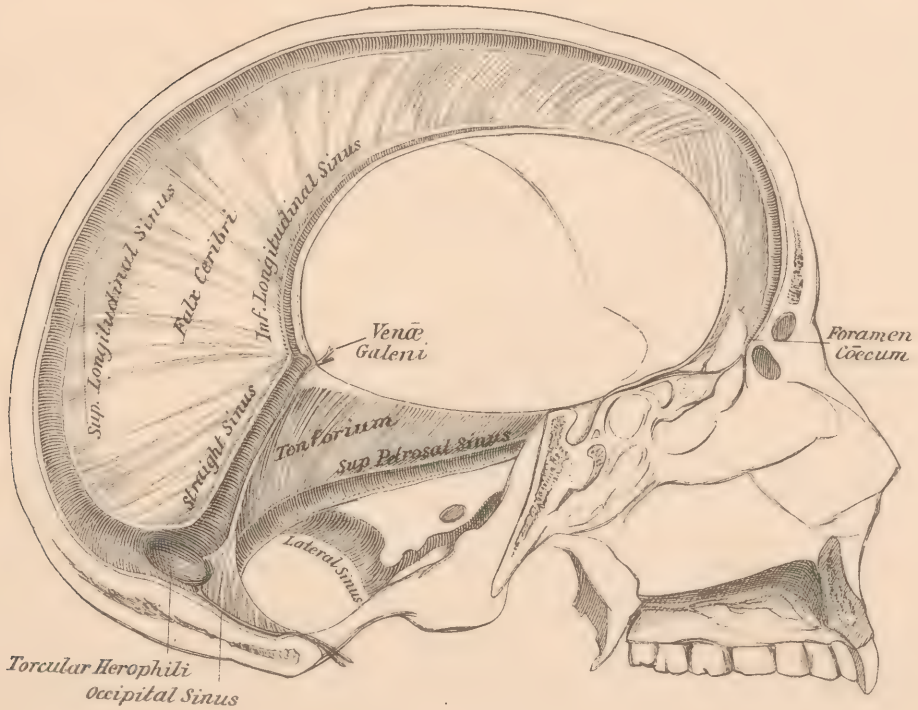


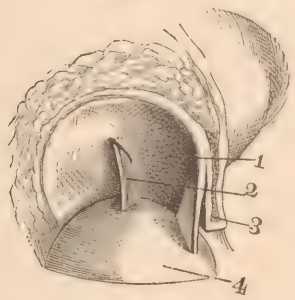
Fig 3.



T. Sinclair & Son, Lith.

Rectus. It also strengthens the internal palpebral ligament, and receives muscular fibres from the Levator Palpebræ muscle. The Inferior Oblique muscle is the only one of the series which is not fixed to some part of the orbital wall by a trabecular band. The function of these bands is obscure, though they seem to check undue action of the muscles.

Fig. 127.



1. The posterior half of the capsule of Tenon. 2. The External Rectus. 3. The upper eyelid. 4. The posterior half of the sclera.

The muscles themselves are united by the fascia in such wise that imperfect sheaths are seen inclosing them. The existence of such sheaths is denied by Liebreich, but most authorities agree in using the term "sheath" in the sense that the fascia is in relation with the muscles, save at their insertions, as an appreciable connective-tissue envelope. The sheaths of the External and Superior Recti muscles are continuous with the external portion of the fascia; the sheaths of the Internal Rectus and the two oblique muscles are continuous with the internal portion of the fascia; while the sheath of the Levator Palpebræ gives off slips of attachment to both the above-named portions. Occasionally, dispersed muscular fibres can be seen passing from one muscle to another, along the lines of their fascial connection.[1]

Boucheron[2] describes a bursa lying beneath the capsule of Tenon and each Rectus muscle, at a point just before the muscle penetrates the fascia.

Bloodvessels.—The arteries of the conjunctiva are derived from the palpebral and lachrymal arteries, which form a series of loops near the margin of the cornea. The conjunctival arteries are movable with the scleral conjunctiva, and in this way are readily distinguished from the subconjunctival, which are derived from scleral vessels, and are disposed in a zone of minute lines, radiating from the corneo-scleral junction. In clinical studies the appearances of the conjunctival and subconjunctival vessels are of importance. The conjunctival vessels become injected, and form coarse networks in conjunctivitis, giving the eye a red appearance. The subconjunctival vessels become full in iritis, but, by reason of the modification of the white color of the sclera, the appearance of the eye is not red but pink, and the conjunctival vessels may be but moderately involved, if at all.—Pterygium is the name given to a vascular connective-tissue growth from the conjunctiva over the cornea.

Remarks.—The clinical applications of a knowledge of the appendages of the eye are the following: (*a*) to the eyelids and conjunctiva; (*b*) to the lachrymal apparatus; (*c*) to the capsule of Tenon.

(*a*) *The Eyelids and Conjunctiva.* The sagging of the lower eyelid, with the escape of tears from the conjunctival space to the cheek, is a sign of facial palsy.—The integument of the eyelid, owing to the absence of fat in the subcutaneous tissue, permits moderate degrees of inflammation to cause great swelling. Owing to the firm union between the conjunctiva and the tarsal cartilages, little disposition exists for effusion to take place between them. The opposite condition obtains between the conjunctiva and the sclera, which permits of the following epitome.

(1) The tarsal cartilages are united to the edges of the orbit by a membrane continuous with their upper edges. The substance of the eyelid outside of the layer of the tarsal cartilages is also attached to the edge of the orbit. Extravasation from the vertex to the eyelids is guided by the above layers to the eyelids, the ocular conjunctiva remaining free.

(2) No barrier exists, however, to the flow of liquids between the conjunctiva and the periocular space. Hemorrhage arising within this space, or from a source within the cranium, will cause the blood-clot and the ecchymosis attending it easily to invade the ocular conjunctiva. Thence it can pass to the palpebral conjunctiva, and in advanced cases may stain the entire thickness of the lower eyelid.

(3) In framing the differential diagnosis of fracture of the skull and of superficial ecchymosis, the following statements may prove useful: Subcutaneous ecchymosis of the eyelids is a sign of hemorrhage having taken place peripherally to the conjunctival sac, or, in other words, outside of the skull, except in the lower eyelid, where it *may* be (when studied with reference to the condition of the entire orbit and its contents) diagnosed as the last stage of peri-

[1] Fr. Merkel, Handbuch der Gesammten Augenheilkunde, 1874, i. 57. This authority is followed in the main features of the account of the capsule of Tenon.

[2] Annales d'Oculistique, lxxx. 1879, 10.

ocular hemorrhage. The presence of subconjunctival ecchymosis is evidence of blood having escaped *behind* or centrally to the conjunctival sac, or, in other words, at some point in the periocular space, and ordinarily from a source *inside* the skull.—In the paroxysms of whooping-cough, extravasations of blood may occur beneath the scleral conjunctiva.—The deposition of products of inflammation beneath the scleral conjunctiva receives the name *chemosis*.

(4) The value of distinguishing the tegumental and conjunctival layers of the eyelid is borne out in Arlt's method of operating for inversion of the eyelashes. The eyelashes belonging to the upper eyelid are raised with the skin layer, by carefully splitting the lid between the row of lashes and the tarsal cartilage. The latter structure, together with the conjunctiva, is allowed to remain in contact with the eyeball. Then, by removing from the skin layer an elliptical piece, and uniting the edges of the wound thus produced, the free edge containing the eyelashes is raised and permanently everted.

Incisions in the eyelids should always be made parallel to the course of the palpebral muscle fibres.

The tactile sensibility of the conjunctiva is very great. The moment the person to whom an anæsthetic agent is administered ceases to wink when the scleral conjunctiva is touched, general anæsthesia may be considered to be established. Sensibility to pain, however, is less decided. High grades of inflammation may exist in the conjunctival tissue, and but slight pain result.

(*b*) *The Lachrymal Apparatus.* The tears flowing from the lachrymal gland pass downward into the conjunctival sac, and thence, flowing across the entire conjunctival space, escape by the canaliculi into the lachrymal sac, and thence, by the lachrymonasal duct, into the nose. If the tears formed be in excess of the capacity of the conjunctival space, they flow over upon the cheek. The clinical conditions related to this act are confined to the lachrymal gland, the conjunctiva, and the apparatus of conduction thence to the nose.

From the position of the *lachrymal gland*, it must follow that enlargement of this body from inflammation, by a tumor or other cause, will compress the contents of the orbit, and tend to press the eyeball downward and inward. Subconjunctival infiltration will occur at the upper and outer portions of the conjunctival sac, and the edge of the swollen gland can be detected at the same point. The gland is liable to become the seat of cystic growths, which are caused by the stoppage of some of its ducts. The retention of tears in the *conjunctival sac* is secured by the tonicity of the muscle fibre, so that when this tonicity is impaired from any cause, the tears collect in the interval between the scleral and tarsal conjunctiva. This condition is especially noted in the lower eyelid of elderly persons. A moderate amount of retention of tears near the lower canaliculus is normal, and has received the name of the *lacus lachrymarum*. The position of the *punctum* of the *lower canaliculus*, as already mentioned, is one favorable to the flow of tears from the lacus directly into the lachrymal sac. The sagging of the lower eyelid, inflammatory depositions, or the presence of any growth which presses upon the punctum from within, may prevent the normal adaptation of the punctum against the sclera. As a consequence, the tears cannot flow readily into the canaliculus, and the efficiency of the lachrymal apparatus is impaired. The *lachrymal sac*, from its intimate union with the periosteum, is liable to involvement in scrofulous diseases of the nasal bones and of the orbit. Extension of inflammatory processes from the walls of the sac to the subcutaneous connective is common, and in acute conditions rapidly involves the region of the lids and face. The amount of infiltration modifies the normal relation of the sac to the superficial parts, and it may become a matter of considerable difficulty to determine the true position of the sac. In connection with this the following rule may prove of value. To ascertain the position of the lachrymal sac, draw a line from the wing of the nose to the outer border of the supraorbital arch. Then bisect the middle of this line by a second, which will, when produced upward, cross the root of the nose. The

EXPLANATION OF PLATE XCIV.

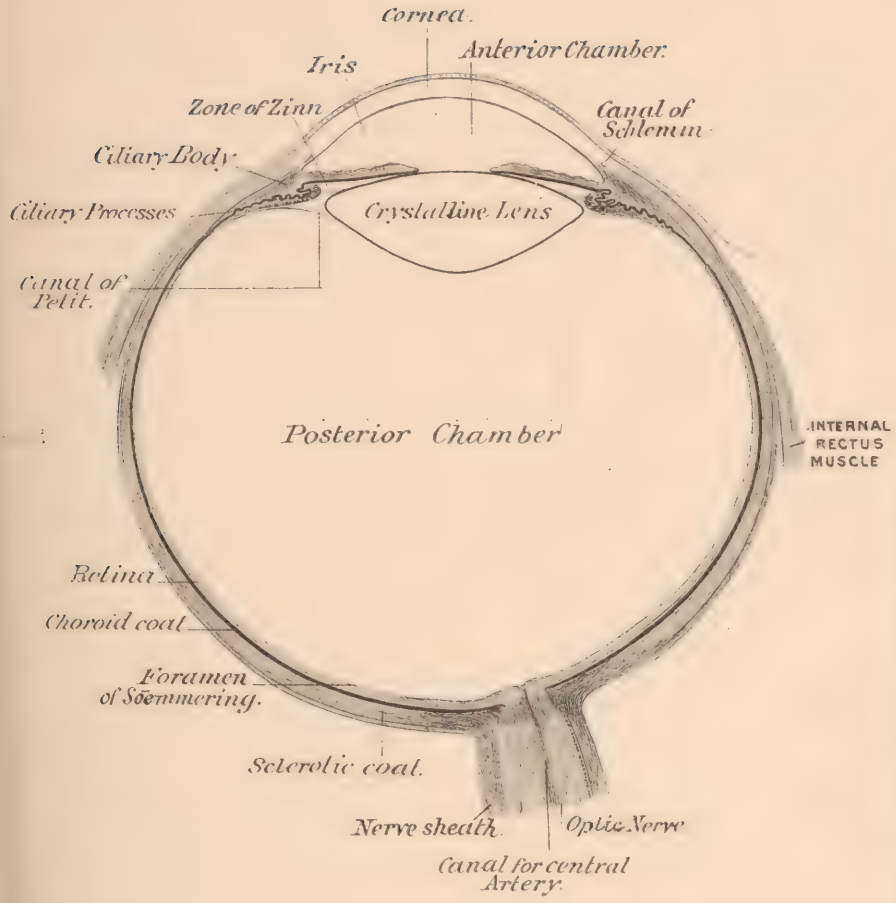
Fig. 1. A horizontal section of the left eye (semi-diagrammatic).

Fig. 2. The plan of construction of the crystalline lens.

Fig. 3. The intraocular image of the optic disk, as seen with the ophthalmoscope.

Fig. 4. The plan of vascular supply of the eye.

Fig. 5. A dissection of the orbit, exhibiting the manner of vascular supply.



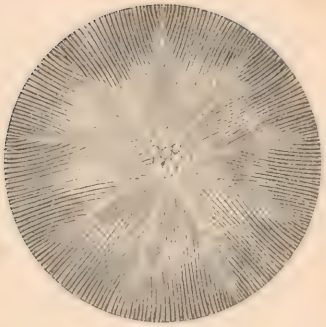
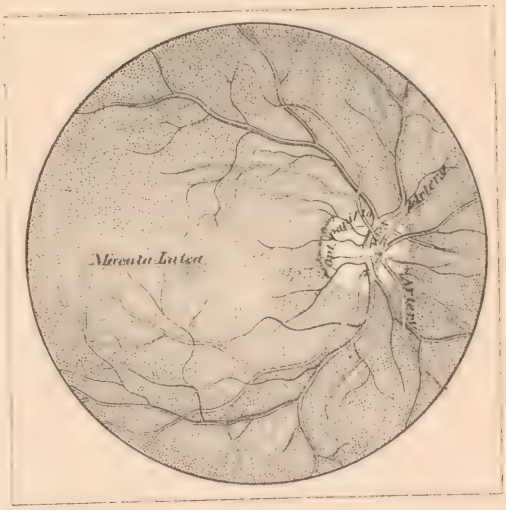


Fig 3



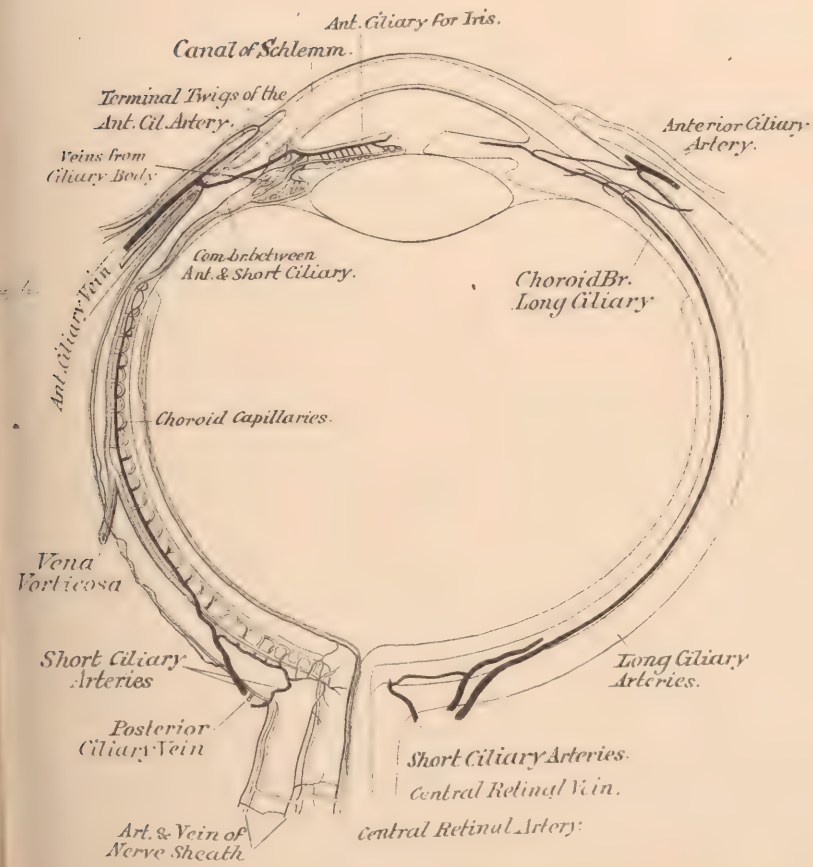
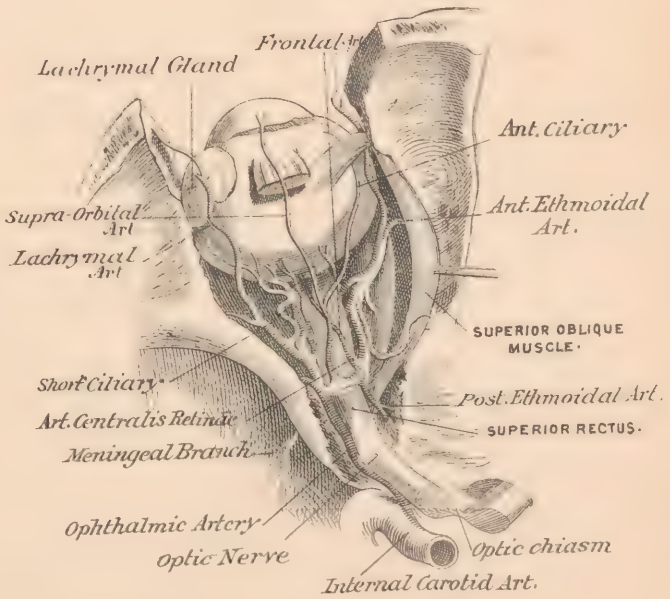


Fig 5.



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second line will exactly cross the position of the lachrymal sac.

(*c*) *The Capsule of Tenon.* In periocular inflammation, tension may be maintained by the resistance presented by the capsule. In performing operations for strabismus, it is of importance to remember that the capsule may aid in maintaining erroneous dispositions of the eyeball after all the muscular bands which have been involved are divided.

THE EYEBALL.

The Eyeball is a subglobular figure, the periphery of which is composed of the cornea and the sclera. It is attached to the optic nerve as a berry is to its stem. The choroid coat and the retina are layers arranged concentrically to the sclera, and the vitreous humor and the lens occupy the interior of that portion of the eyeball defined by the sclera. The aqueous humor lies in the eyeball between the plane of the anterior termination of the sclera and the cornea.

The Eyeball is thus composed of—

The Cornea.
The Sclera.
The Iris.
The Choroid.
The Retina.
The Vitreous Humor.
The Lens.
The Aqueous Humor.

THE CORNEA.

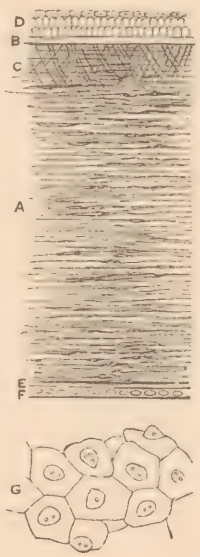
The Cornea is the transparent portion of the outer covering of the eye. It forms a membranous structure, which projects by a distinct sharp curvature in advance of that of the sclera. It is nearly circular in form, measuring five lines transversely, which is slightly in excess of the perpendicular diameter, and is $\frac{1}{22}$ to $\frac{1}{32}$ of an inch in thickness (the outer edge becoming somewhat the thicker). The cornea constitutes about one-fifth of the periphery of the eyeball, and is attached to the sclera as a watch crystal is set in its case. Anteriorly it is bathed by the lachrymal secretion, and posteriorly by the aqueous humor.

Viewed from behind, the cornea is circular in form, and presents a sharply defined border; viewed from in front, it is more oval in form, and presents a border which insensibly merges into that of the sclerotic coat. In a section which involves both the cornea and the sclera, the border of the cornea is seen to be slightly bevelled from before backward, owing to the disposition of the sclera to overlap the cornea in front.

Structure. The cornea, when studied by histological methods, presents for examination the following layers:—

(1) The anterior epithelial.
(2) The anterior basement membrane.
(3) The proper substance of the cornea.
(4) The posterior membrane.
(5) The posterior epithelial.

Fig. 128.



The plan of construction of the cornea. *A*, *C*, the proper substance; *B*, anterior basement membrane; *D*, the anterior epithelial membrane (all the cells should be nucleated); *E*, the posterior basement membrane; *F*, the posterior epithelial membrane; *G*, cells of corneal epithelium (more highly magnified).

(1) The anterior epithelial membrane (first layer) (*D*, Fig. 127) is continuous with the ocular conjunctiva. The cells of the first row are columnar; the others are at first rounded, but become flattened toward the surface.

(2) The anterior basement membrane (Bowman's membrane) (*B*, Fig. 127).

(3) The proper substance (parenchyma of the cornea) (*A*, *C*, Fig. 127) is apparently homogeneous, but under the action of reagents a complicated structure, based upon modifications of connective-tissue, is demonstrable. The essential features of such modifications are seen in the alternation of planes or laminæ (some sixty in number), within which are recognized numbers of connective-tissue corpuscles, elongated in the lines of the lamellar planes. Indistinct interlacings of fibrils may be seen at the margins of the cornea, assuming toward the surface an oblique arrangement.

Placed between the laminæ is a matrix or connecting medium containing small, flattened spaces. These are homologous with the connective-tissue spaces elsewhere. Within them are situated irregularly stellate corpuscles

(corneal corpuscles). The cornea is non-vascular in health, but is nourished by the colorless ingredients of the blood passing through the lamellar interspaces.

(4) The posterior basement membrane (membrane of Descemet, membrane of Demours, posterior elastic lamina) (*E*, Fig. 127) is better defined than the anterior. It is a firm, elastic, resistant membrane, which is continuous from the corneal margin through a network of fibres (ligamentum pectinatum iridis) with the anterior basement membrane of the iris, as well as with the choroid and sclerotic coats. In the angle between the iris and the cornea just beyond the posterior basement membrane is a system of *cavernous spaces* (spaces of Fontana) which are occupied by the aqueous humor. (See Fig. 129.)

(5) The posterior surface of the preceding membrane is covered with a single layer of epithelial cells (*F*, Fig. 127), which presents the same features as those in the other portions of the anterior chamber.

Extending around the cornea, just in advance of the corneo-scleral junction, is a small canal called the *canal of Schlemm*. It is lined with epithelial cells, and is probably of the nature of a venous sinus.

The nerves from forty to forty-five in number are derived from the ciliary nerves. They freely anastomose between the laminæ, forming the primary plexus, which supplies for the most part the substantia propria. From this a secondary plexus is formed, which lies beneath the epithelium, and sends delicate branches among the epithelial cells.

Variation.—The curves of the cornea are subject to many minute variations which determine the nature of optical defects included under the term astigmatism. Infrequently the cornea is conical in form.

Remarks.—The cornea is of a singularly tough consistence, and serves, by this quality as well as by its thickness, the purpose of an admirable organ of protection to the iris. While frequently the seat of lesion, the result of blows or wounds from missiles moving with great force, it successfully resists the more common causes of injury.

The laminated structure of the cornea is demonstrated in studying the effects of diseased action. In the vascular opacity of the cornea (pannus), which so frequently accompanies granular lids, the anterior layers of the cornea, in the opinion of some observers, is the seat of a new growth of cells. Similar growths occur beneath the anterior epithelial membrane. Pus are sometimes seen lying between the laminæ of the cornea, and constitutes the condition which has received the name of *onyx*. The laminæ present various degrees of resistance to ulcerative action, as is well illustrated in the so called serpiginous ulcer.

The aqueous humor pressing against a deep corneal ulcer can bulge forward the base (through the elastic quality of the posterior basement membrane) until it forms a convex swelling on the front of the eyeball.

The marginal border of the cornea is subject to a form of fatty degeneration which has received the name of the *arcus senilis*.

The cornea is nourished by imbibition of the plasma, or by the circulation of this fluid through the lymph-spaces. In abnormal conditions, bloodvessels are developed, as in *pannus*, and may become large and abundant. The repair of injuries of the cornea is often followed by dense white opaque scars.

In performing the operation of extraction of the crystalline lens for cataract, it is necessary to remember that the opening through which the lens is to be passed must be a trifle larger than the lens itself, so that the size of the incision must be proportioned to the diameters of the lens. The margin of the cornea, as seen in the undissected eye, is overlapped by the sclera. An incision through the sclera a short distance back of this margin will permit the knife to enter the anterior chamber. Such a section is selected in performing the first stage of the operation for extraction of the lens as devised by Von Graefe.

THE SCLERA.

The Sclera (sclerotic coat) is the fibrous framework or envelope of the eyeball. The anterior part as exposed within the palpebral fissure, where it is called the "white of the eye," is covered with the conjunctiva. The rest of the ball is surrounded by

EXPLANATION OF PLATE XCV.

Figs. 1 and 2. The structure of the cornea, as seen when magnified.

Fig. 3. A vertical frontal section of the left eye and of the nasal chamber of the same side.

Fig. 4. A semi-diagrammatic view of the stem of the brain, exhibiting the origin of the optic nerves.



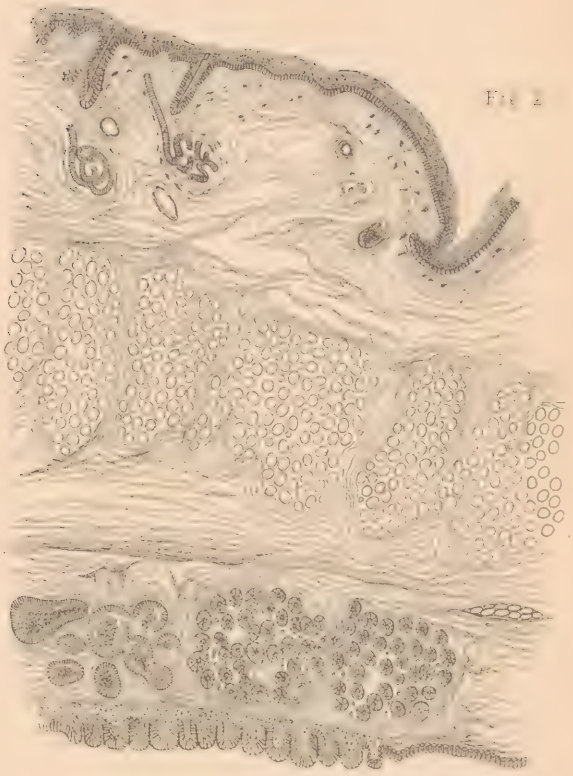


Fig. 3.

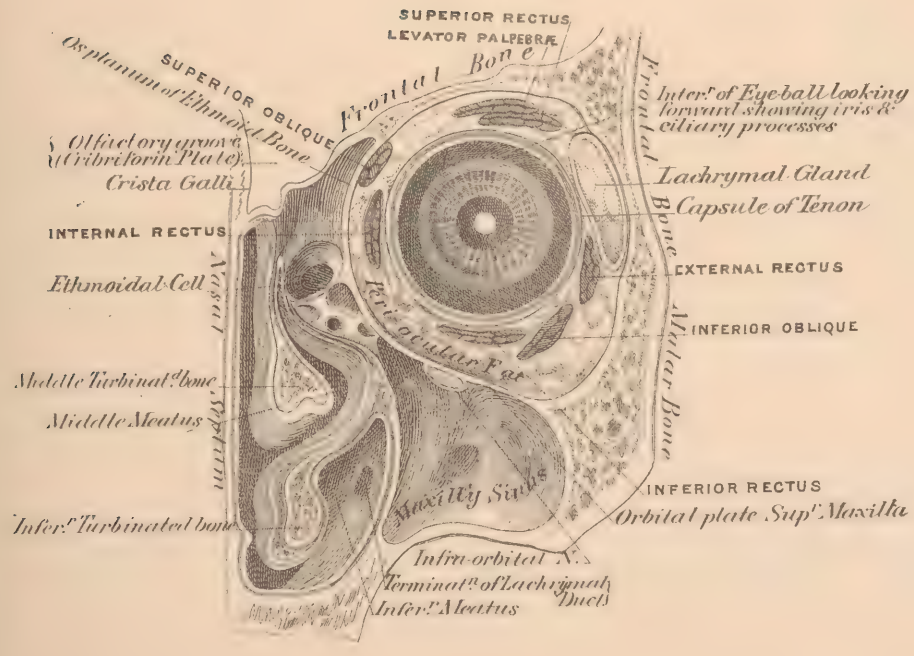


Fig. 4.

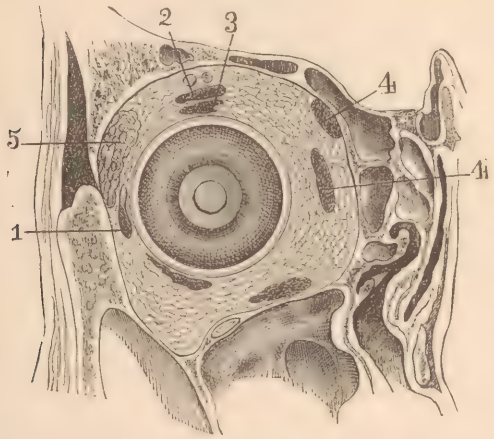


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fat, from which it is separated by the capsule of Tenon, and receives the insertion of the straight and oblique periocular muscles.

The sclera is thicker posteriorly than anteriorly. It is cup-shaped in form, and is perforated behind, or at its base, by the optic nerve; while it is open in front for union with the cornea. The corneal opening is a little wider without than within. The optic nerve is received within the sclerotic coat one-tenth of an inch to the inner side of the antero-posterior axis of the eyeball. The nerve-fibres yield their neurilemma to the sclerotic coat, while passing through a sieve-like arrangement of scleral fibres, which has received in consequence the name of *lamina cribrosa*.

Fig. 129.



A frontal section of the orbit and contents—anterior half. 1. External Rectus; 2 Levator Palpebræ; 3. Superior Rectus; 4. Superior Oblique; 5. Lachrymal gland. The eyeball is surrounded by fat. The osseous structures to the median side of the orbit represent the ethmoidal cells and other parts of the ethmoid bone and vomer. To the lateral side are seen the malar bone and the Temporal muscle.

The membrane is white upon its outer surface, but brownish upon its inner, which has, from this fact, been called the *lamina fusca*. Upon this surface are found faint groovings for the long ciliary nerves.

Structure.—The fibres of the sclera arrange themselves into two more or less distinct sets, viz., the longitudinal and transverse. Between these a number of elastic filaments are sparsely distributed. The fibres of the tendons of the straight muscles are continuous with the longitudinal fibres, while those of the oblique muscles are continuous with the circular. The sclera is pierced about the entrance for the optic nerve by a number of canals, which extend perpendicularly or obliquely through the membrane, and are occupied by the ciliary arteries and nerves. The membrane is further pierced toward the corneal margin by several minute openings for the entrance of veins.

Remarks.—The sclerotic coat, when softened by inflammatory process, may be distended by intra-ocular pressure to such a degree as to permit the choroid coat to be seen through the outstretched interlacing bands.—The coat is thicker than is normal in hypermetropia and in phthisis bulbo, and is thinner than is normal in myopia; from its tough fibrous character it bears well the presence of sutures.

The eyeball, when the eyelids are closed, is turned slightly upward. If a pointed instrument pierce the centre of the upper lid, it will not wound the cornea, but it will wound the sclera at a point below the cornea.

THE CHOROID COAT.

The Choroid Coat (choroidea) is the vascular membrane of the eye. It is of a dull brownish color, and lines the sclerotic coat. Anteriorly it is continuous with the iris, and posteriorly is pierced by the optic nerve.

The choroid coat presents two layers, an outer and an inner.[1] The *outer layer* (lamina supra-choroidea) is a thin connective-tissue layer, resembling the lamina fusca of the sclera. It contains lymph-spaces which are continuous with the lymph-space of the capsule of Tenon. The *inner layer* (choroid proper) is the vascular layer, being composed of a network of vessels. The *arteries* are derived from the ciliary artery, and pierce the sclera around the optic nerve. They pass at first forward and finally inward, to end in the

Fig. 130.



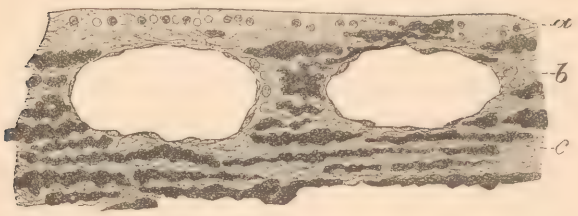
The ciliary processes and iris, seen from behind. *a*, choroid coat; *b*, ciliary processes; *c*, iris-radiating fibres; *d*, iris-circular fibres.

radiate capillaries.—The *veins* of the choroid coat form figures somewhat similar to those of the terminal arteries, but pierce abruptly the sclerotic mem-

[1] Formerly the eighth layer (pigment layer) of the retina (*q. v.*) was described with the choroid coat.

brane about midway between the cornea and the entrance of the optic nerve.

Fig. 131.



Transverse section through the choroid coat of the ox. Magnifying power about 250. *a*, chorio-capillaris, outside this is a layer of elastic fibrils, shown on the left of the figure; *b*, the layer of large veins, venæ vorticosæ; *c*, the outer layer, containing numerous pigmented connective-tissue cells flattened in a direction parallel to the surface.

At the terminal portion of the choroid membrane, viz., at the point of junction with the iris, are found a number of folds of the choroid coat, known as the *ciliary processes*. They are club-shaped—the thicker ends projecting inward—about seventy in number, and arranged radially about the peripheral margin of the iris. Between the processes which form the larger group are placed a number of smaller ones. —Collectively the ciliary processes constitute the *ciliary body*.—This term is also used to include the entire thickness of the choroid, which corresponds in position to the ciliary processes. In the latter sense the ciliary body may be said to be that thickened portion of the choroid coat which is defined internally by the ciliary processes, externally by the sclera. It is continuous posteriorly with the choroid proper, and anteriorly with the iris. It is occupied by the ciliary muscle.

The Ciliary Muscle is a small triangular group of unstriated muscular fibres, having a tendinous origin from the corneo-scleral junction to the inner side of the canal of Schlemm. It is composed of two sets of fibres, the radiate and the circular. The *radiate fibres* (meridional fibres) are inserted into the ciliary processes. The *circular fibres* (circular ciliary ligament) lie to the inner side of the preceding fibres, and pass circularly around the eye, within the zone of the ciliary processes.

The ciliary muscle, while properly embraced within the account of the choroid coat, is found to be in

Fig. 132.



Bloodvessels (injected) of the iris and choroid membrane of the eye of a child. *a*, Capillaries of the choroid; *b*, position of ora serrata of the retina; *c*, bloodvessels derived from *d*, those of the ciliary processes, and from *e*, those of the iris; *f*, capillary network of the pupillary border.

a measure distinct from it, inasmuch as its radiate fibres are firmly attached to the corneo-scleral junction. The structure separates the choroid membrane from the iris, as the ciliary processes separate the pigment layer of the retina from the uvea of the iris.

THE IRIS.

The Iris is a circular muscular membrane, situated in the anterior chamber between the lens and the cornea. It is placed nearly in a vertical plane, its posterior surface resting (near the centre) on the capsule of the lens. The iris is perforated by the round opening of the *pupil* (pupillary margin), which is not situated in the axis of the eye, but is a little

EXPLANATION OF PLATE XCVI.

Fig. 1. A longitudinal section of the optic nerve and of the optic papilla magnified.

Fig. 2. A diagrammatic figure of the lachrymal apparatus.

Fig. 3. A dissection of the face, showing the position of the lachrymal nasal duct. (For *lachrymal duct*, read "lachrymo-nasal duct.")

Fig. 4. A horizontal section of the right eye and orbit, exhibiting the relation of the optic nerve and of the internal and external recti muscles.

Fig. 5. A transverse section of the optic nerve magnified.

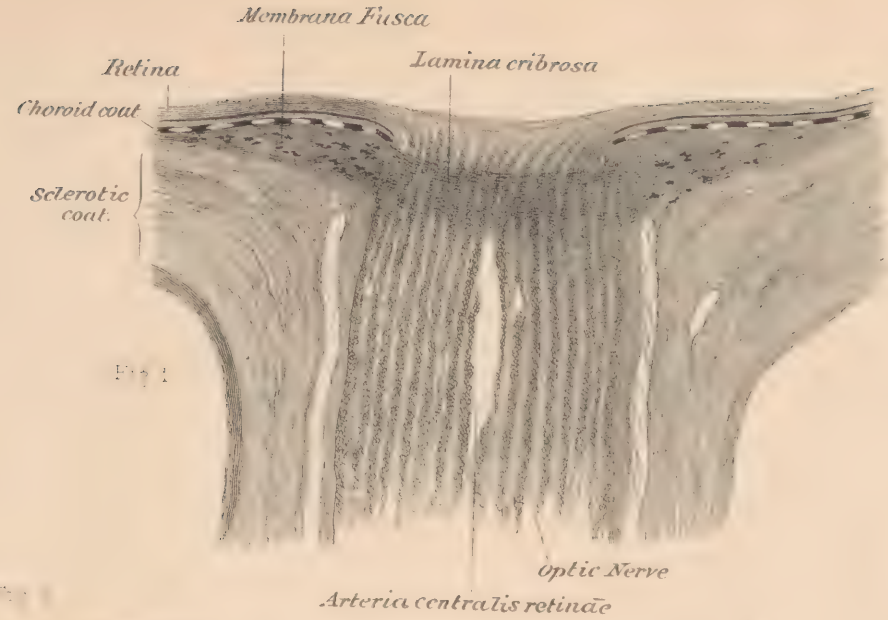
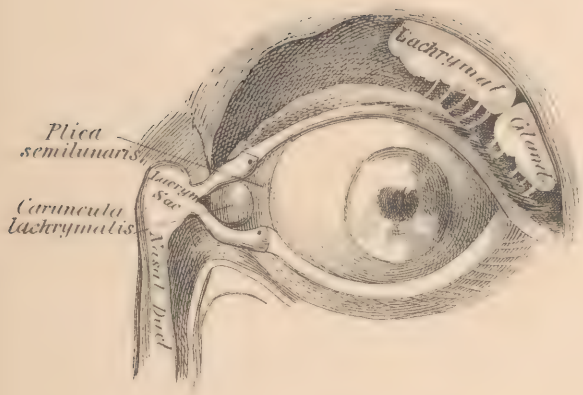
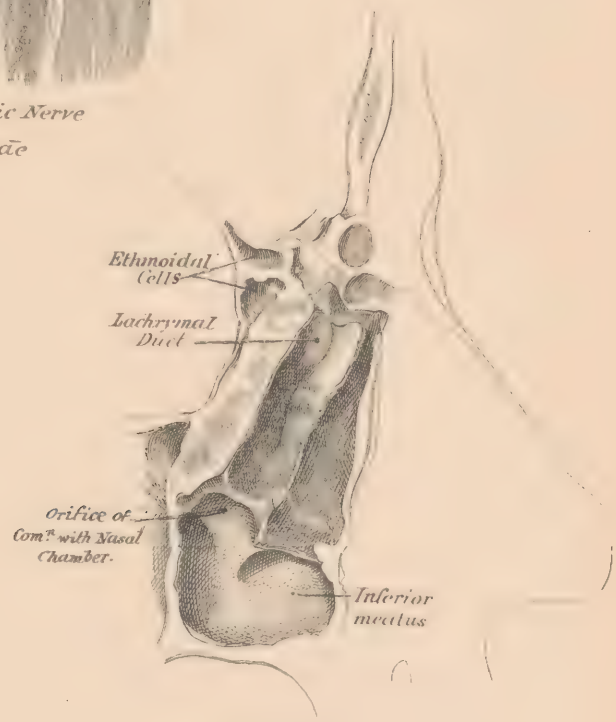


Fig 1





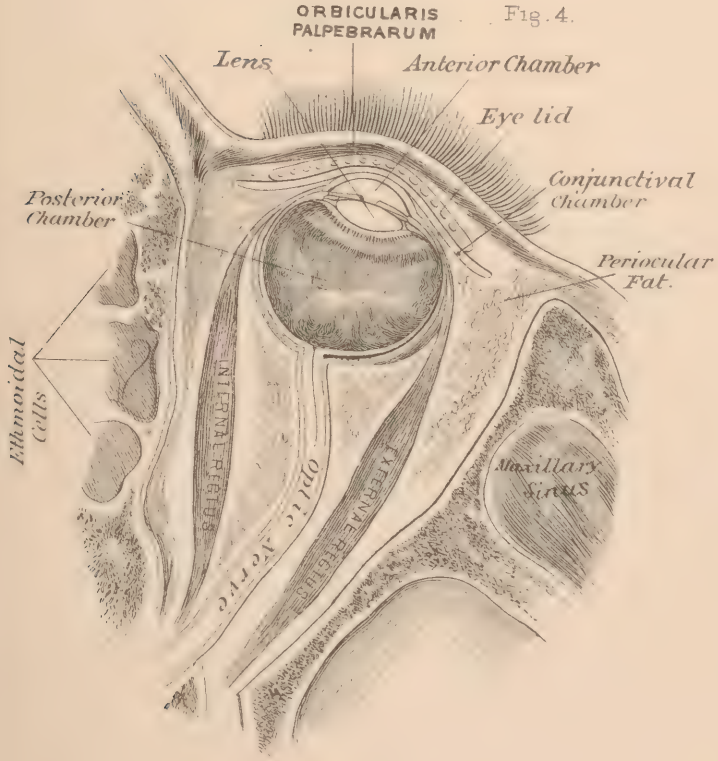


Fig. 4.

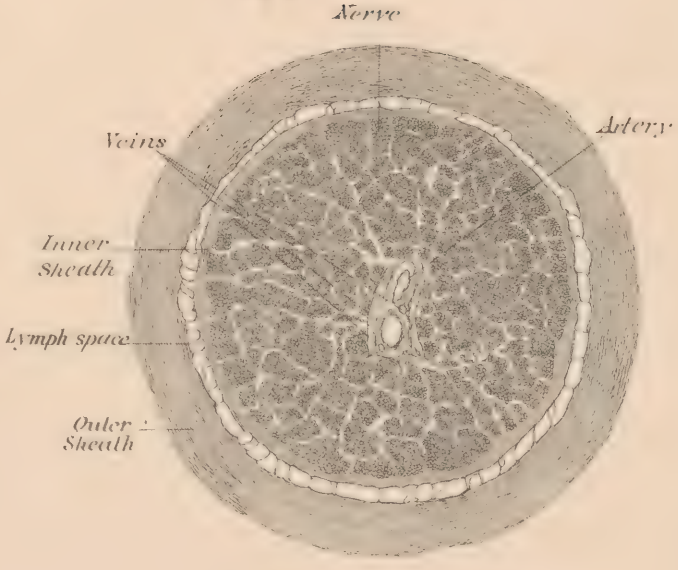
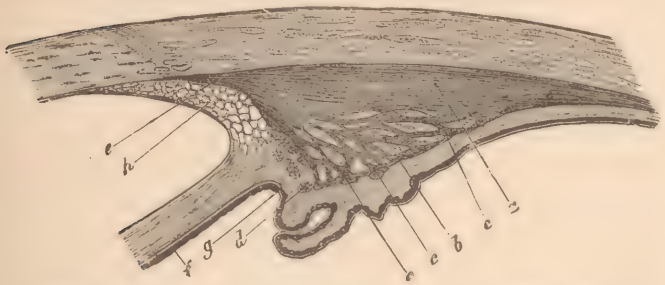


Fig 5

T. Sinclair & Son, Lith.

downward and to the inner side. The outer fixed margin (ciliary margin) of the iris is continuous with the choroid coat posteriorly, with the ciliary muscle

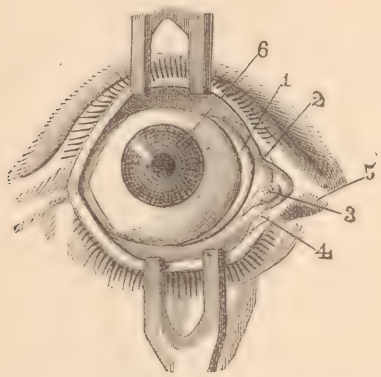
Fig. 133.



Section through the ciliary body and the corneo-scleral junction, showing the ciliary muscle, and system of spaces at the continuity of cornea and iris. *a*, choroid; *b*, radiating fibres of ciliary muscle—the small group of circular fibres are seen lying to the median side of the radiating; *d*, a transverse section of a bloodvessel; *f*, the uvea of iris; *g*, the pigment layer of the ciliary body; *h*, the spaces of Fontana (rendered too conspicuous).

externally, and with the peripheral fibres of the membrane of Descemet anteriorly.

Fig. 134.



The eyeball seen from in front, the eyelids being separated by lid-retractors. 1, semilunar fold; 2, 4, puncta; 3, caruncle; 5, internal palpebral ligament; 6, iris.

The *anterior surface* is variously colored, and marked, for the most part, with an open network of irregular, rounded spaces, having wavy borders. Near the pupil the markings are radial. The *posterior surface* (uvea of iris) is black.

The diameter of the pupil in health is, when contracted, about one-twentieth of an inch; when dilated, one-third of an inch.

Structure.—The iris exhibits three distinct layers:

(1) A layer of epithelial cells covers the front of the iris, which is continuous with the layer upon the posterior surface of the membrane of Descemet.

(2) The muscular layer gives form to the anterior surface of the iris, and presents two distinct divisions. The pupillary margin is surrounded by a well-defined continuous muscle, one-fortieth of an inch wide, situated upon the posterior surface of the membrane, and called the contractor. The area between the circular layer and the margin is traversed by a number of radiate bundles, which, as they converge toward the pupil, occasionally anastomose at acute angles. They are inserted for the most part among the outermost of the fibres of the circular layers, a few reaching deeper. The interspaces between the muscular bundles are occupied by connective-tissue and pigmented cells, together with numerous bloodvessels and nerves.

(3) The uvea. The posterior surface of the iris is covered with a layer of black pigment-cells termed the uvea. This layer is continuous posteriorly with the similar layer constituting the pigment-layer of the retina.

Scattered throughout the iris are numbers of pigmented connective-tissue cells, black or of various shades of yellow and brown. These, with the pigmented cells of the uveal layer, are the agents which produce the coloration of the iris.

Pupillary membrane, or membrana pupillaris, is the name given to an embryonic structure which occupies the position of the future pupil. This membrane is vascular, its vessels being arranged in loops projected from the continuity of the membrane with the iris.

Bloodvessels.—The iris is an exceedingly vascular structure, being supplied by the terminal branches of the long ciliary, as well as by those of the anterior ciliary arteries, by branches of the lachrymal artery, and by muscular branches of the ophthalmic.

The *long ciliary arteries*, two in number, pierce the sclera on either side of the optic nerve, and pass forward between the sclerotic and choroid coats as far as the ciliary muscle, at which point they enter the iris. They anastomose at the outer margin of the membrane, forming a ring, the *circulus major*. Branches from this ring supply the ciliary muscle and the iris, the latter forming, by anastomosis, a second ring about the pupillary margin, the *circulus minor*.

The *anterior ciliary arteries* (short ciliary arteries) pierce the corneo-scleral junction, and supply the ciliary bodies. Their capillaries unite with these, and join the circulus major.

The *ciliary nerves*, twelve to fifteen in number, penetrate the sclerotic near the optic nerve, and pass forward in company with the long ciliary arteries. The nerves are, in the main, distributed to the ciliary muscle, within which they form a plexus, and from this the iris is supplied.

Variations.—A condition of congenital cleft or fissure in the choroid and iris has received the name of coloboma. The iris may be absent. The pupil may be placed eccentrically. In rare instances two pupils may be present in a

single iris.—The iris is subject to slight variation in its position. The portion of the iris resting on the lens lies a little in advance of the remaining portion of the iris, the exact degree of prominence being determined by the shape of the lens; thus it is less prominent in myopia than in hypermetropia.

Remarks.—The choroid membrane, by reason of the slight attachment existing between it and the point of entrance of the optic nerve, as well as by reason of the powerful contraction of the ciliary muscle, is, as the result of long-sustained contraction of the muscle, pulled forward. Inspection of the interior of the eye with the ophthalmoscope will often exhibit crescentic figures of a white color outlined at the margin of the optic papilla, as the result of this forward traction exerted upon the choroid membrane. The white color represents the amount of exposure of the sclera, thus deprived of the choroidal lining. Ophthalmologists term these lesions the effects of "choroidal drag." They are typically expressed in neglected cases of hypermetropia.

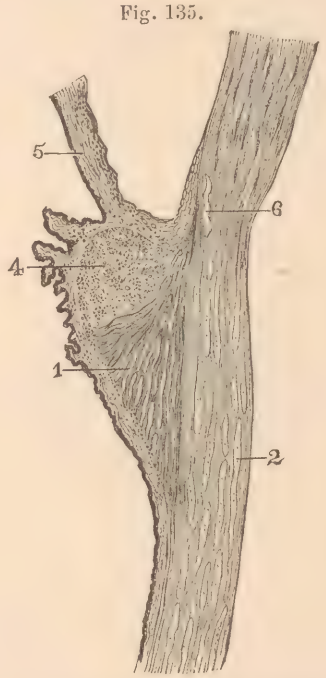
The disposition of the choroidal vessels is believed by E. Jaeger[1] to hold a direct relation to the localization of the effects of malnutrition. Thus, the retina, as a consequence of the arrangement of the vessels in the choroid membrane, is liable to invasion by diseased action (such, for example, as the effects often seen in the eye from Bright's disease of the kidney); this action is localized in areas, which are limited by the subdivision of the choroidal vessels themselves. Jaeger defines these areas as follows: "One composed of the arterial circle of Zinn, which surrounds the optic papilla; another formed by the arteria centralis retinæ, which supplies the retina; another composed of the short posterior ciliary arteries, which supply the posterior half of the choroid membrane; and still another composed of the long ciliary arteries, which supply the iris and the anterior half of the choroid membrane; the short anterior ciliary arteries also take part in the formation of this area."[2]

The iris, in clinical as in anatomical studies, may be considered as a specialized portion of the choroid membrane. It is a membranous sphincter, whose function is to determine the amount of light which enters the eyeball. The pupil is contracted in accommodation for near objects, and in sleep. Hence, the pain that follows attempts at inspection of minute objects in irritated states of the iris, and the disposition to nocturnal exacerbations of pain in iritis. The pupil is dilated in accommodation for far objects.

A portion of the iris is excised in the operation for extraction of cataract, and for the arrest of glaucoma. It may by abnormal processes become adherent to the cornea, and be prolapsed by the effects of wounds, etc.

The ciliary muscle is devoted to the special work of modifying the shape of the crystalline lens (see account of the lens, p. 598). In extreme and long-sustained irritation, as in hypermetropia, numerous reflex characteristic symptoms arise. The muscle itself undergoes hypertrophy, as is represented in the accompanying sketch, fig. 135.

Fig. 135.



Section of the ciliary body, showing the hypertrophy of the circular fibres of the ciliary muscle in hypermetropia. 1, the radiate fibres of the ciliary muscle; 2, the sclera; 4, the circular fibres of the ciliary muscle; 5, the iris; 6, the canal of Schlemm.

In diminished traction of the ligament of the lens, as is noted in myopia, the muscle presents an appearance which is in marked contrast to that of hypermetropia, the circular fibres being rudimental or absent, as is seen in fig. 136.

THE RETINA.

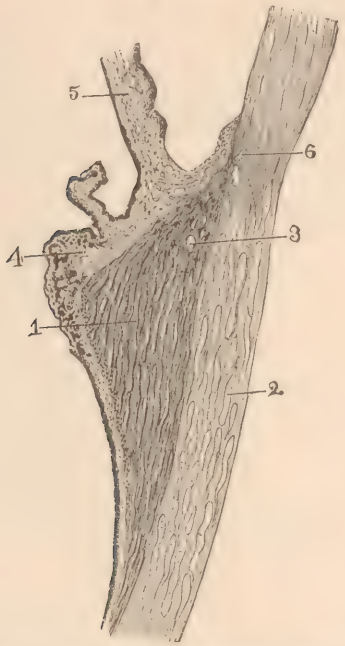
The Retina is the inner tunic of the eyeball, and immediately surrounds the vitreous body. It is a transparent membrane of a delicate pink color during life. It measures in thickness from the $\frac{1}{200}$th of an inch anteriorly to the $\frac{1}{50}$th of an inch posteriorly. The retina is in connection behind with the optic

[1] Ergebnisse der Untersuchung. mit dem Augenspiegel, etc., 1876, 16.

[2] A. G. Heyl, Med. News, 1884, xv. 327.

nerve, and at least one of its layers is prolonged from this structure. It is marked posteriorly at the point of entrance of the nerve by the optic disk, and in

Fig. 136.



Section of the ciliary muscle, showing absence of the circular fibres of the ciliary muscle in myopia. 1, the radiate fibres of the ciliary muscle; 2, the sclera; 3, the section of a vessel; 4, the ciliary processes; 5, the iris.

front by a number of radiate folds—the ora serrata. Between the ora serrata and the ciliary body is a thin membrane, the pars ciliaris retinæ, which, according to Hyrtl, is continuous with the ciliary body and uvea. The optic disk is not in the axis of the organ, but lies a little to the inner side. At a point corresponding to the axis is a small oval spot, the macula lutea, which measures one-twentieth of a line in diameter.

Structure.—The retina is a membrane of great complexity. It is composed of eight layers, associated with a delicate framework termed the fibres of Müller. Counting from the inner or centric side, we recognize—

Internal limiting membrane.

1. The nerve-fibre layer.
2. The ganglionic layer.
3. The inner molecular layer.
4. The inner nuclear layer.
5. The outer molecular layer.
6. The outer nuclear layer.

(These constitute the "granular layer" of some authors.)

External limiting membrane.

7. The layer of rods and cones.
8. The pigment-layer.

(This constitutes the pigment-layer of the choroid coat of some authors.)

(1) The nerve-fibre layer is derived from the fibrils of the optic nerve. It is composed of non-medullated filaments having the thickness of brain fibres, which are arranged in flat wavy bundles directed forward. It is almost wanting at the macula lutea.

(2) The ganglionic layer consists of large ganglionic cells. The processes of the cells are so arranged that one unbranched filament commonly passes obliquely inward, and is lost within the nerve-layer. Others pass vertically outward and are lost within the inner molecular layer. The cells are most numerous at the macula lutea.

(3) The inner molecular layer is almost structureless. It is much thicker than the outer molecular layer, and is composed of numerous minute granular masses imbedded in a structureless matrix.

(4) The inner nuclear layer is made up of three to four rows of cells, whose nuclei are so large as to give the impression that they are free, but in each cell, a cell-wall can be detected, with cell contents at either end of the oval nucleus.

(5) The outer molecular layer (internuclear) resembles the inner of the same name, but is much thinner.

(6) The outer nuclear layer is distinguished from the inner by its association by continuity with the rods and cones, its cells fulfilling the function of axial supports. Those beneath the cones present a double contour-line on each, while the others, continuous with the rods, present a single contour line and are filamentous. The nuclei in this layer present a transversely banded appearance.

Fig. 137.



Portions of the layer of rods and cones seen from without. *k*, microscopic appearance of the outer surface of the retina over the yellow spot, where there are only cones; *l*, appearance of the retina near the yellow spot—a single circle of rods surrounding each cone; *m*, appearance of the middle of the retina, a large number of the rods surrounding each cone. In all three figures the larger rings represent the cones, and the smaller ones the rods seen endwise.

(7) The layer of rods and cones (Jacob's membrane, columnar layer) is the most highly specialized of the retinal layers. It is a remarkable group of slender columnar forms interspersed among sparsely distributed conical figures, which are shorter than the rods. The rods are absent over the macula lutea. The rods and cones are closely related structures. The basal portions are nearly structureless, but the apices are linearly striated, and those of the cones may present transverse markings. The layer is easily seen when the sclera and the choroid membrane from a fresh eye are immersed in cold water.

(8) The pigment-layer is a single layer of simple hexagonal cells, charged with black pigment-matter, whence delicate processes protrude between the rods and cones. The outer surfaces are flat. It lies in close contact with the

choroid membrane, with which it has been recently identified. The pigment-layer is evolved from the same primordial structures which yield the remaining retinal structures.

Variations.—In brunettes and negroes the quantity of pigment-cells is increased. In ophthalmoscopic examination of such subjects the eye-ground is dusky. In blondes and albinos the opposite conditions obtain, and the eye-ground, owing to the small quantity of pigment-cells, is of a delicate pink color.

The Fibres of Müller, known also as the sustentacular tissue, constitute the framework analogous to the connective-tissue stroma of other organs. By the apposition of the broad surface of their conical basal portions, an apparent continuous structure is formed—the so-called *membrana limitans interna*, situated within the layer of nerve-fibres. At the junction of the layer of rods and cones with the outer nuclear layer, the *membrana limitans externa* is similarly formed by the termination of the offsets of the framework. Some of the cells of the inner nuclear layer are seen as appendages to the fibres of Müller.

The macula lutea. The structure of the retina at this spot measures one-tenth of an inch. It is of a yellow color, due, it is thought, to a fluid (believed by Luschka to be of a fatty character) filling in the interior between the cones. About the centre of the macula is the pit-like depression called the *fovea centralis*. The cones alone are present over this spot, the rods being wanting, while the remaining layers here attain their greatest tenuity.

Bloodvessels.—The retinal vessels, according to Hyrtl, are derived from—

The artery of the sheath.

The artery between the neurilemma and medulla of the optic nerve.

The special central artery, which sends off loops upon the retina, and minute branches into the fovea centralis.

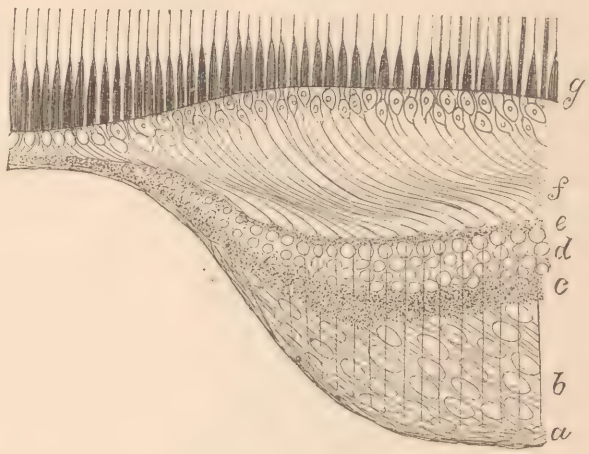
The blood reaches the layer of rods and cones, none going beyond the inner nuclear layer.

The "veins resemble capillaries in structure, their walls consisting of a single layer of epithelioid cells." The structure of the ora serrata and pars ciliaris consists only of "elongated columnar cells with the pigmentary layer placed externally."

The vessels, as seen by the ophthalmoscope in the living eye, present some distinctive features. Thus the veins of the "eye-ground" pulsate, while the arteries are without pulsation. The contours, both of the arteries and the veins, are imperfectly defined. The chief source of the images of both sets of vessels is the blood-currents themselves.

Remarks.—The retina after death assumes a ground-glass or milky appearance. The macula lutea becomes inconspicuous, and a pair of transparent folds (*plica centralis*) is seen on either side of the macula lutea, forming a pit-like depression—the fovea centralis, which, from the thinning of the retina at this point, permits the pigment-layer to become visible through it.

Fig. 138.



From a vertical section through the macula lutea and fovea centralis. *a*, Nerve-fibres; *b*, ganglion-cells; *c*, inner molecular layer; *d*, inner nuclei; *e*, outer molecular layer; *f*, cone-fibres; *g*, cones.

In addition to the remarks made under the head of the choroid membrane, it may be said that the retina may be detached from the choroid membrane over large surfaces. The retina is a favorite seat for gliomatous tumors.

THE VITREOUS BODY.

The Vitreous Body (vitreous humor) is a jelly-like, transparent structure occupying the posterior four-fifths or two-thirds of the eyeball, to the shape of which it conforms, except in front. Here the sides gently curve inward, forming a central dish-like depression for the lens.

The vitreous body is in direct contact with the retina, but is firmly held to the *pars ciliaris retinæ*, and also to the ciliary body. This attachment constitutes the zone of Zinn (ciliary zone, suspensory ligament), and is of great importance, since it not only gives general support to the vitreous body, but yields points of attachment to the capsule of the lens. So intimate is this connection, that attempts at separation bring away with the vitreous body particles of the pigment-layer of the pars ciliaris retinæ. When thus detached, the vitreous body is seen to be marked by a series of raised folds and intermediate depressions (ciliary portion of the vitreous body), answering to the processes of the ciliary body.

The limiting surface of the vitreous body is called the hyaloid membrane. It is smooth, of great deli-

cacy of structure, and differs from the interior of the vitreous body by becoming markedly differentiated in front, at the region of the attachment above mentioned. In the description of the termination of the hyaloid, it is usual to state that it divides opposite the ciliary body into two leaflets, one passing in front and the other behind the lens. But, while a continuity can be proved to exist between the hyaloid and the capsule of the lens, these structures are so peculiar that they deserve definition for the same reason that the iris is described separately from the choroid. In this way the hyaloid may be said to terminate in the zone of Zinn, the structure of this portion of the capsule of the lens deflected inward from the beginning of the zone, differing scarcely at all from the general features of the vitreous body. The zone of Zinn is distinctly fibrillated in a radial manner, very stout, and somewhat elastic. It measures three lines in diameter on the temporal side, and from two to three on the nasal. It is continuous in front with the suspensory ligament of the lens and the capsule.

Some authors describe all the structures between the hyaloid membrane and the capsule as the zone of Zinn, which thus presents a posterior fixed portion at the ciliary region and an anterior free portion corresponding to the suspensory ligament.

Structure.—The vitreous humor is composed of exquisitely delicate fibrils of a connective-tissue-like structure, having an arrangement as yet imperfectly understood. It is thought, however, that a radiate type of fasciculation can be detected extending from the periphery toward the centre, and surrounded by a clear, gelatinous fluid. That such a stroma is present can be shown by the fact that a film remains after filtering the fluid-contents, and that wounds of the vitreous body do not necessarily end in loss of all the fluid.

An occasional free nucleus can be seen as well as wandering leucocytes exhibiting amœboid movements. The hyaloid membrane is richly supplied upon its inner surface with tessellated corpuscles which may be looked upon as aggregated leucocytes. In the fœtal state the vitreous body is perforated by the central artery of the retina.

The canal of Stilling is a passage the existence of which was for a long time in dispute. It is now, however, asserted by Schwalbe that a coloring matter can be injected through it by way of the pia mater sheath of the optic nerve.

Remarks.—The vitreous humor can repair injuries to itself and losses of volume to a remarkable degree. The loss of small amounts of the vitreous humor is a frequent occurrence in the operation for cataract.—The chamber of the vitreous may be the seat of formations of cholesterine crystals and of connective-tissue growths. Some varieties of *muscæ volitantes* are due to flakes of connective-tissue growths being tossed about in the chamber of the vitreous by the motions of the eyeballs. The vitreous humor may receive and encapsule minute foreign bodies. Its nutrition is dependent entirely upon the vessels of the choroid membrane, and, as a result, many if not all of its inflammatory conditions are accessories to primal states of the choroid membrane.

The canal of Petit. Between the suspensory ligament (zone of Zinn), the posterior capsule, and the lens is a delta-shaped space called the canal of Petit. Its walls are opposed during life, but can be inflated with air in dissection or in decomposition,[1] when a beaded appearance due to the lumen of the canal being narrower at short intervals is presented.

The tips of the ciliary processes lie free in the posterior chamber of the eye, over which passes a delicate structureless membrane which reaches to the ciliary border of the iris.

THE CRYSTALLINE LENS.

The Crystalline Lens is a biconvex, transparent structure situated between the vitreous humor and the iris. It is of a rounded form and inclosed within its own capsule, the anterior portion of which is thick and is continuous with the suspensory ligament. The posterior portion of the capsule is a thin layer of hyaloid membrane like that which lines the dish-like depression in the front of the vitreous body. At the side the rounded border of the lens forms the base of the delta-shaped canal of Petit, whose remaining boundaries are defined by the layers of the suspensory ligament. The lens measures one-third of an inch (eight mm.) from side to side, and one-fifth of an inch from before backward. It is flatter in front than behind, and does not completely fill its capsule, a small quantity of a clear fluid being normally found therein, the so-called liquor of Morgagni.

Structure.—The lens is composed of an assemblage of lamellæ, which are developed from cells. Each measures $\frac{1}{5000}$th inch in diameter, and presents a slightly serrated edge. Upon section it is observed to be 6-sided and prismoidal. A lamella when examined in its formative stage is observed to be nucleated. These nuclei, however, early disappear or become inconspicuous, and can be demonstrated only by the action of reagents. The space between the lens and the anterior capsule is occupied by a single layer of nucleated cells.

[1] M. Aeby (Arch. f. Ophth., xxviii. 1882, 111) describes a method by which the canal of Petit can be studied with great advantage in an eye which has been subjected to maceration for several days in water.

The lamellæ are softer toward the periphery than at the centre of the lens; the latter part, from this fact, receiving the name of the *nucleus of the lens.* When the lens is macerated or hardened in chromic acid, there can be seen upon the anterior and posterior surfaces three lines or rays diverging from a central point, which divides the surface into three compartments, each compartment being composed of about one hundred and twenty lamellæ. The two surfaces do not correspond with respect to the position of these lines, those upon the anterior surface alternating with those upon the posterior. Thus the lines present a Y-shaped figure behind, while in front the Y is inverted, thus ⅄. The lamellæ abut against the margin of these lines, and extending around the lateral margin, they assume a slightly wavy appearance.

Variations.—The lens in the child is more convex than in the adult, but is flattened in the aged.

Remarks.—The lens in conditions of diseased action may become opaque, with various degrees of softening or hardening. The cortical portions of the lens may be soft, while the interior portions become hard. The lens, after the thirty-fifth year, becomes of firmer consistence than at any earlier period of life.

The degree of firmness of the lens holds a direct relation to age. The lens resists the influence of the ciliary muscle just in proportion as its parts become of firmer consistence and of diminished elasticity.

THE AQUEOUS HUMOR.

The Aqueous Humor is the clear watery fluid occupying the anterior and posterior chambers of the eye.

The Anterior Chamber.—The anterior chamber is the space between the cornea and the iris, being separated by the last-named structure from the posterior chamber, except at the pupillary orifice.

The Posterior Chamber.—The posterior chamber is the space between the iris and the anterior capsule of the lens. The ends of the ciliary process project slightly within this chamber. From the contact of the pupillary margin of the iris with the capsule, the two chambers do not communicate in the ordinary movements of the iris. When the pupil is widely dilated, however, the two chambers are thrown into one.

Remarks.—The aqueous humor reaccumulates rapidly after loss as by a wound or by paracentesis. The chamber of the aqueous humor is the occasional seat of parasitic invasion, and may lodge a foreign body. Pus when formed within the anterior chamber gravitates and forms a layer of pus at the bottom of the chamber, which has received the name of hypopion.

Variations.—Instances of persistent hyaloid artery are rarely met with. Dareste[1] has observed that in hernia cerebri, or in exencephala, and in cyclops, the eyeball is imperfectly formed, the lens and vitreous humor being notably defective.

The nerves of the retina are rarely provided with nerve-sheaths. When such sheaths are present, the appearance of the eye-ground is remarkably distinct from that of the normal eye, since the nerve-sheaths appear in the image of the ophthalmoscope as white opaque tracks along the course of the nerves.

THE EAR.

The Ear is the organ of hearing. It is divided into three portions as follows:—

The Outer Ear.
The Middle Ear.
The Internal Ear.

The Outer Ear comprises the auricle and the external auditory meatus.

The Middle Ear comprises the tympanic chamber with its contents and appendages. The contents of the tympanic chamber are the *ossicles*, the *malleus*, the *incus*, and the *stapes*, which form an association of bones connected externally with the *tympanic membrane*, and internally with the internal ear. The appendages of the middle ear comprise the mastoid cells and the Eustachian tube.

The Internal Ear includes the true organ of hearing and receives the *auditory nerve.* It communicates in the skeleton with the middle ear by two openings, the oval and the round window. In the undissected subject, the *oval window* is occupied by the base of the stapes and its annular ligament, and the *round window* by a membrane.

THE OUTER EAR.

The Outer Ear is composed of—

The Auricle.
The External Auditory Meatus.

The Auricle (pinna) is an appendage to the external auditory meatus which is designed for the reception of waves of sound. Its form is nearly elliptical, wider above than below, and is composed of an

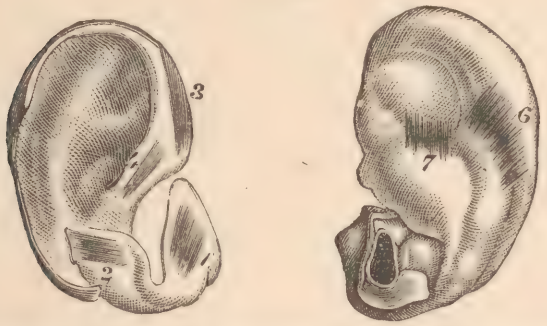
[1] Comptes Rendus, xcv. 44.

irregularly sculptured fibro-cartilage, connective tissue, muscles, and fat, the whole figure being covered with integument. The auricle in man is rudimental as compared with the same structure in many lower animals.

The *fibro-cartilage* gives form to the auricle, the lobe alone excepted. It is attached to the tympanic portion of the temporal bone, and its depressions and elevations correspond with those of the auricle as a whole.

The eminences on the anterior surface answer to depressions on the posterior surface, and *vice versâ* The features of the fibro-cartilage not seen from without are the *cauda helicis*, a tapering process of inconstant proportions which passes down into the base of the lobe of the ear, a small process answering to the external free margin known as the *process of the helix* (spine of the helix), and the various slits

Fig. 139.



The cartilage of the auricle. The figures 1, 2, 3, 4, 5, 6, 7 are placed on or near fascicles of muscle-fibres.

or fissures which are inconspicuous in the body of the cartilage, but which are well seen between the tragus and helix, and between the ring-like fissures of the concha (fissuræ Santorini) as it approaches the *pars tympanica*. The skin of the anterior surfaces of the auricle is held firmly to the perichondrium, in order to prevent an accumulation of fat from interfering with the reception of waves of sound. Fat is present in small quantity on the posterior surface of the auricle, where the skin is not firmly fixed to the perichondrium. In the ears of many healthy persons, well-defined folds of skin extend from the post-auricular space to the hinder surface of the auricle.

The following are the main points in the nomenclature of the external ear: An outer border termed the *helix*, beginning as a thin elevated central root sharply limited above and in front, but becoming more obscure along its outer border, and finally lost before reaching the lobe (fig. 1, Plate XCVII.).

Within the periphery of the helix is a second eminence—the *antihelix*. Starting below the root of the helix, the antihelix describes a shorter curve to terminate in two fork-like processes, the upper blunt, the lower sharp, which are lost behind the acute anterior border of the helix. The depression between the helix and antihelix is termed the *fossa of the helix;* that between the forks of the antihelix the *fossa of the antihelix*. The antihelix is continuous below with the *antitragus*, and thence through the line of the *intertragus notch* with the *tragus*.

The space between the antihelix, antitragus, and tragus is called the *concha*, and is crossed along its floor by the root of the helix.

Bloodvessels.—The *arteries* of the auricle are derived from the posterior auricular and temporal branches of the external carotid and at times from the occipital artery. The branch of the posterior auricular artery which passes to the front part of the auricle effects entrance from below through the fissure in the fibro-cartilage between the helix and concha.—The *veins* empty into the external jugular vein, though small venules join the temporo-maxillary vein.

The *nerves* of the auricle are derived from the superficial cervical plexus through the auricularis magnus, from the auricular branch of the trifacial, and posteriorly from the facial nerve. The auricular branch of the pneumogastric nerve, after giving a branch to the mucous membrane of the middle ear, also sends a branch to the auricle—a distribution in illustration of a fact often observed (see p. 461) that a nerve supplying a deep-seated region will be expected to send a second branch to the superficial parts of the same region. The point at which the nerve effects entrance into the temporal bone, namely, at the outer border of the jugular foramen through an opening near the styloid process, is also the region corresponding to the first visceral cleft of the embryo.—The exact areas of distribution of the above nerves can sometimes be determined in paralysis of the separate branches.

Remarks.—Gruber[1] mentions a case in which the *cauda helicis* passed some distance into the lobe. It had been perforated in the procedure of piercing the ear. Severe inflammation of the auricle supervened, which extended to the retro-maxillary space, where an abscess formed.—The posterior surface of the auricle becomes swollen in erysipelas.

Ossifications of the cartilage are occasionally met

[1] Lehrbuch die Ohrenheilkunde, 1870, 1871.

with, not so much, however, as a result of advancing years as the effect, according to Garrod,[1] of gout. Toynbee[2] has seen similar deposits following atheroma in the insane.

A minute blunt point, variable in size and sometimes present on the ear of one side only, projects from the anterior margin of the helix. The process is worthy of notice, since in the judgment of Darwin[3] it is the homologue of the structure composing the upward pointed extremity of the auricle in quadrupeds. Lucæ[4] ascribes the process to the effects of intra-uterine inflammation and pressure.

Variations.—The variations in the form of the auricle are numerous. The lobe, while as a rule pendulous, with a free anterior border, may occasionally be found confluent with the lines of the face and neck. In questions of identity the examination of the auricle may prove of value, and in many instances the form is hereditary. According to Gruber, a congenital deformity of the auricle has been observed in many generations.

The External Meatus (external auditory canal) (fig. 3, Plate XCVII.) extends from the auricle to the membrane of the tympanum. It is composed of two portions: the bony portion belonging to the pars tympanica of the temporal bone, and the cartilaginous portion belonging to the auricle. These two structures, while apparently continuous, are separated by a small irregular membranous space.

The direction of the meatus is sinuous, with an inclination slightly downward and forward. The union of the cartilaginous with the bony portion is marked by a ridge on the floor of the passage. That portion to the inner side of the ridge is directed downward, forward, and inward. That to the outer side of the ridge is directed downward, forward, and outward. The latter obliquity is better marked than the former. The canal may be made straight by traction of the auricle backward and slightly upward.

The entire length of the meatus ranges from nine to fifteen lines; of this, one-third the distance corresponds to the cartilage and two-thirds to the bone. The inclination of the antero-inferior surface of the wall, from the oblique position of the tympanic membrane, is downward and inward; the canal is widest at the junction of the cartilaginous and bony portions, the diameter ranging from two to five lines.

The bony meatus is in indirect clinical relation to the temporo-maxillary articulation. Hence, fractures of the skull from blows upon the front of the lower jaw may include the tympanic bone. (See p. 124.)

The anterior part of the cartilaginous portion, being in relation with the parotid gland, may be involved by intumescence of that body.

Relations.—The boundaries and relations of the bony portion of the external meatus are best understood by recalling the fact that the anterior and inferior portions alone arise from the tympanic portion of the temporal bone, while the superior and posterior pertain to the squamous portion. Von Tröltsch has shown that the cavity of the middle ear extends both above and behind the external meatus at its tympanic end, and that in some individuals the distance between the meatus and the dura mater is so slight that extension of inflammation from the meatus to the membranes of the brain is possible.

At the entrance of the meatus the canal presents a subrounded opening, its shortest diameter being the antero-posterior. Within the canal is wider and slightly compressed from below upward. The floor is somewhat depressed in front of the tympanic membrane, where, according to Von Tröltsch, foreign bodies may become lodged.

Structure.—The meatus is lined with thin integument. This is perforated by the orifices of numerous minute glands (ceruminous glands) which secrete a waxy substance. These glands are most numerous within the inner half of the cartilaginous portion of the canal, although a few can be traced as far as the membrane itself. They belong to the convolute type, and are lodged in the subdermic connective tissue. Some of them are sufficiently large to be received in corresponding depressions in the cartilage.

Bloodvessels.—The arteries are derived from the posterior auricular branch of the facial, and from the deep auricular branch of the internal maxillary which supplies the tragus.

Remarks.—In children the tympanic membrane is nearly horizontal.—Pus from the parotid gland may open into the meatus.—In aged edentulous individuals the condyle of the lower jaw may press against the cartilaginous portion of the meatus and induce deafness.—Owing to the curved direction of the meatus, perforations of the tympanic membrane along the lower portion may escape notice.

THE TYMPANIC MEMBRANE.

The Tympanic Membrane (membrane of the drum) is a subrounded partition between the external meatus and the chamber of the tympanum. It is firmly lodged in the groove of the tympanic bone by the aid of a circle of fibrous tissues known as the *annulus tendinosus*.

The tympanic membrane measures from four and a half to five lines in its longest or vertical diameter, and four in its shortest.

[1] Nature and Treatment of Gout, 1859.
[2] Trans. Path. Soc. Lond., 1860, xi. 225.
[3] Descent of Man, 1871, 22.
[4] Virchow's Archiv, xxix. 6, 2.

A description of the tympanic membrane embraces—

(1) The layers of which the membrane is composed.
(2) The topography of the outer surface.
(3) The topography of the inner surface.

(1) *The layers of which the membrane is composed.* The tympanic membrane is composed of three layers: the outer, the middle, and the inner.

The *outer layer* (dermoid layer) is epithelial in character, and is continuous with the skin of the external meatus. In macerated specimens of the ear, the skin of the meatus can be removed as the finger of a glove from the finger.

The *middle layer* (fibrous layer, membrana propria) is composed of two layers of fibres: the outer or radiate, and the inner or circular layer. The radiate fibres are stouter than the circular, and are attached to the tympanic bone, converging thence to the centre of the membrane. The circular fibres are weaker toward the centre than elsewhere. Many of them originate upon the membrane, having no extrinsic attachment. Interspersed through the membrane are other fibres which do not demand detailed description.

The *inner layer* (mucoid layer) is thin, and is covered with a tessellated epithelium, continuous with that of the middle ear. Brücke[1] states that the epithelial cells are at times ciliated like those through the rest of the tympanic chamber. Villus-like projections have been found by several observers[2] attached to this surface of the membrane.

The handle of the malleus is attached to the membrane by a special mechanism. It lies in a groove of hyaline cartilage, which is converted into a canal at the base of the handle, and invests the short process. Some degree of motion probably obtains between the manubrium and its curious groove-like sheath. The handle and short process of the malleus modify the shapes of the two surfaces, and serve as the basis of their topography.

(2) *The topography of the outer surface.* When the tympanic membrane is examined through the external meatus (fig. 4, Plate XCVII.), it is seen to be inclined downward and inward, with a slight inclination forward. Thus it is seen to be deeper below and in front than above and behind, while the inferior and anterior part is on a deeper plane than the superior and posterior.

[1] Physiologie, ii. 215.

[2] Gruber, Studien über das Trommelfell, 20.

The handle is distinctly seen upon the surface as a long scythe-shaped process directed obliquely downward and backward, and terminating a little below the centre of the membrane. Above the handle and nearly in a line with it is the short conical process of the malleus. Passing backward from the short process to the posterior margin of the membrane, is the *posterior tympanic fold.* Extending forward from the same point or origin to the anterior margin is a second shorter fold, the *anterior tympanic fold.*

The short process and the two tympanic folds form a line which serves to separate the two divisions of the outer surface of the tympanic membrane.

The surface below the line is of a grayish pearl tint with a slight yellowish admixture. It is depressed at the apex of the manubrium to form the *umbo.* Between the umbo and the margins the surface is drawn inward, making the membrane assume a funnel-shaped figure, the sides of which are remarkable for presenting convex surfaces outward. Since the light falls upon that portion of the membrane which reflects the rays most nearly at a right angle, a triangular cone of light (pyramid of light) is seen to extend downward and forward with its apex at the centre of the umbo. The semi-transparency of this portion of the membrane permits the long process of the incus and the stapes to be occasionally seen. The transmission of the outline of the promontory is also possible.

The smaller region above the line of the short process and tympanic fold is of a uniform reddish color, and is not translucent. The tympanic membrane is here thinner than elsewhere, and is covered by a membrane, ordinarily not distinguished except by dissection, termed the *membrane of Shrapnell* (membrana flaccida).

The outer surface of the membrane is also divided into quadrants. This is an inexact method, but has been found convenient. If a line produced along the axis of the manubrium be cut by one drawn through the end of the same process from before backward, unequal quadration of the membrane results. Those portions behind the first line are termed the posterior quadrants, and those in front the anterior quadrants. These are again divided by the line drawn from before backward in such wise that there are defined an antero-superior and a postero-superior quadrant as well as an antero-inferior and postero-inferior quadrant. Each of these portions is again divided into a superior and an inferior.

(3) *The topography of the inner surface.* The *inner* surface of the tympanic membrane is *convex.* It is marked by two folds which form the boundaries of the pockets of Von Tröltsch. The *anterior pocket* is a depression between the base of the long process and the neck of the malleus, the anterior malleolar ligament, and the fold of mucous membrane answering to the chorda tympani nerve. The *posterior pocket* is open below, and is situated at the posterior superior part of the membrane, and is formed by a fold of membrane running toward the handle of the malleus.

A third pocket or pouch is described by Prussak and Brunner. This cavity, according to C. Burnett,[1] is defined behind by the neck of the malleus, below by the upper surface of the short process, in front by the membrana flaccida, and above by the external mallear ligament.

Remarks.—Since the action of the Tensor Tympani muscle is to rotate the malleus and to make tense the tympanic membrane, it will be seen that the effects of such rotation should be carefully studied as the membrane is exposed at the bottom of the external auditory meatus. The anterior quadrants are deepened; the handle of the malleus is retracted and appears foreshortened, its narrowest edge presents itself toward the membrane, while the free end of the process is rounded and thickened. These characters when taken together are pathognomonic of increased inward tension and retraction of the membrane, and are of great value to the physician in studying this condition as a correlative of chronic aural catarrh.

Lucæ[2] has observed a movement of the membrane in respiration.

The rare appearance upon the outer surface of the membrane of the apparent duplication of the short process is explained as follows: the process has slipped out of its sheath, the process counting for one eminence, the sheath for the other.

The membrana flaccida is often the seat of acute changes, in which the rest of the tympanic membrane does not participate. On the other hand, congestive, particularly catarrhal, conditions are apt to be announced by increased redness and lividity of this membrane. The student, therefore, should make himself familiar with its normal appearances in the living subject.—The membrana flaccida is sometimes greatly relaxed, and individuals have the power by inflating the middle ear to cause it to bulge outward. This condition is not of necessity associated with any diminution of hearing.

The third pouch may become filled with mucus or pus, and it may be, in consequence, ruptured. Many cases of earache, which present no features of distension of the drum-head proper, or, in fact, of the region of the membrana flaccida, may be relieved instantly by puncturing the latter at the third pouch. The point to be selected for the puncture lies just above and in front of the short process.

Variations.—The plane of the tympanic membrane varies with respect to the axis of the external meatus. In children the inclination from above downward is more oblique than in the adult. In some adults the membrane is inclined forward and inward.—The membrane of Shrapnell is an exceedingly variable portion of the tympanic membrane. It is often perforated by an exceedingly minute canal situated close to the short process, and called the *foramen of Rivini.* In the opinion of some writers, the membrane of Shrapnell is closed in health—the opening being the result of morbid action or of imperfect development.—Numerous minute variations in the details of the membrane both in structure and color are to be detected, which have received little or no attention.

THE TYMPANIC CHAMBER.

The Tympanic Chamber is a narrow, irregular space between the outer wall of the labyrinth and

[1] Treatise on Diseases of the Ear, 82.
[2] Archiv für Ohrenheilkunde, 1864, i. 96.

EXPLANATION OF PLATE XCVII.

Fig. 1. The auricle.

Fig. 2. The temporal bone, showing the chamber of the tympanum displayed from within, and the malleus and incus as well as the Eustachian tube in position.

Fig. 3. A frontal (vertical transverse) section of the chamber of the tympanum and the bottom of the external auditory meatus.

Fig. 4. The tympanic membrane, seen in position at the bottom of the external auditory meatus. The membrane is divided into fourths by two dotted lines crossing each other at the position of the umbo.

Fig. 5. The temporal bone so divided as to display the inner wall of the tympanic chamber.

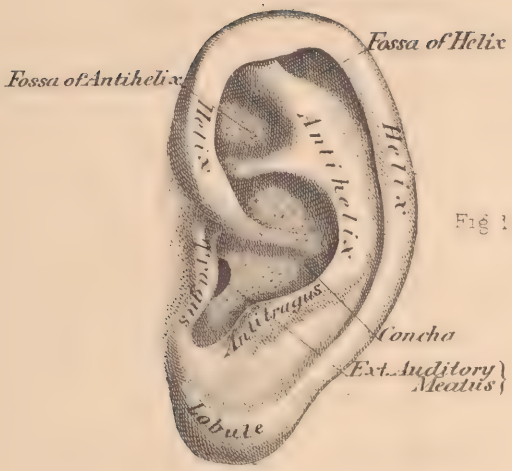


Fig 1

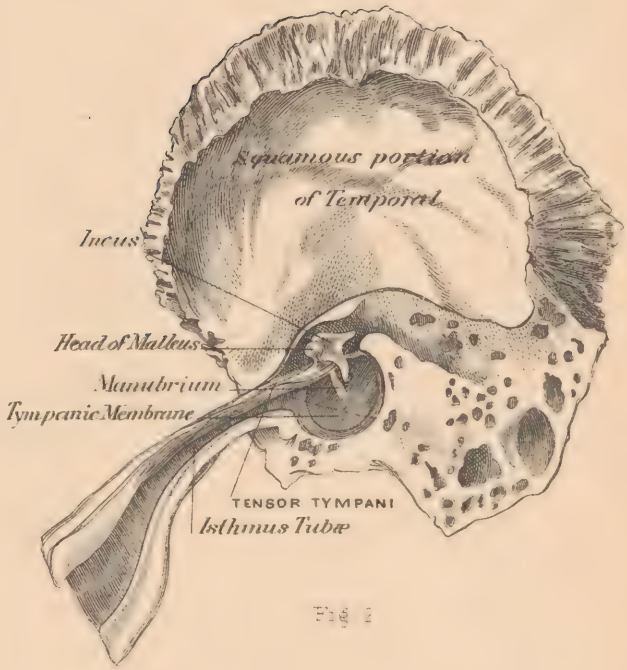


Fig 2

Fig 3

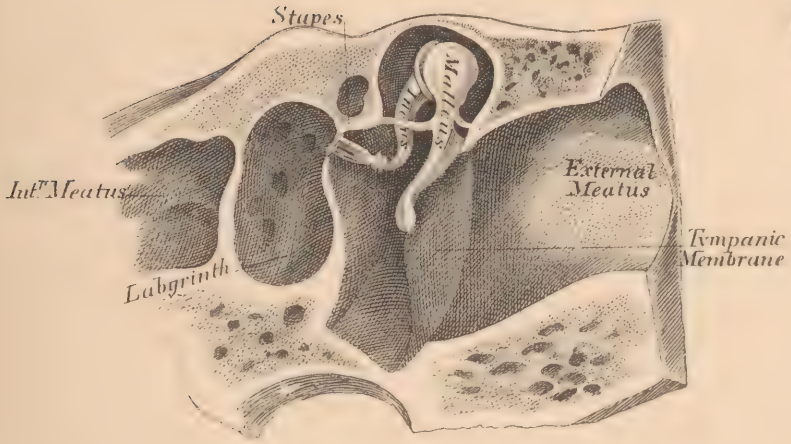


Fig 4

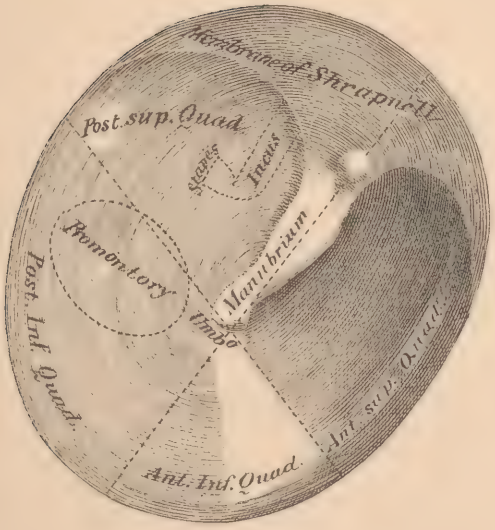
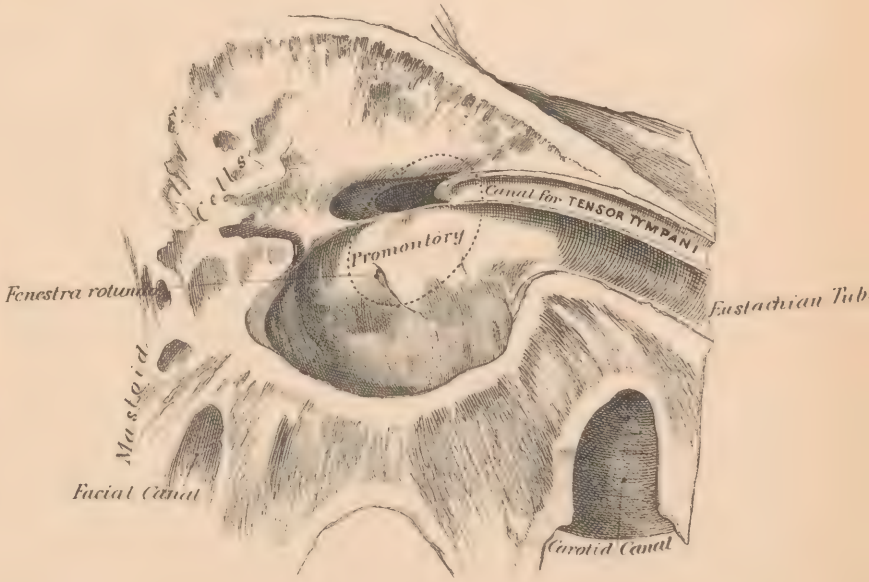


Fig 5



T. Sinclair & Son, Lith.

the tympanic ring and membrane. It communicates in front with the Eustachian tube, and behind with the mastoid cells.

It is filled with air through the Eustachian tube, is lined with mucous membrane, and contains the ossicles.

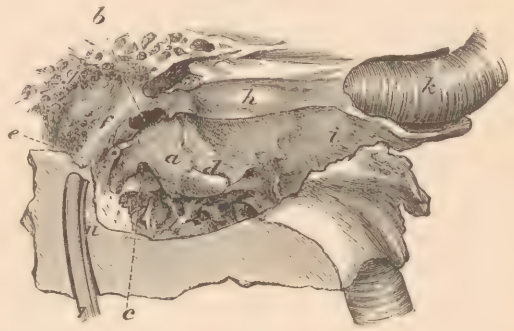
The chamber is four and a half lines high, two lines in its greatest diameter, and one-twentieth of a line in its smallest, *i. e.*, between the umbo and the promontory. For convenience in description six sides are recognized: an inner and an outer, a superior and an inferior, an anterior and a posterior.

The inner wall.—The inner wall (labyrinthine wall), fig. 140 (fig. 5, Plate XCVII.), is osseous, and answers in great part to the outer wall of the labyrinth. Its most conspicuous feature is the *promontory*, a rounded, irregular eminence, lying between the oval and round windows, and overlooking the latter. It is caused by a projection outward of the basal turns of the cochlea. Above the promontory is a reniform opening, lying in a shallow depression parallel to the tympanic membrane. It is called the *oval window*, and is occupied by the base of the stirrup. Below this, and concealed from view at the meatus, is a smaller rounded opening, the *round window*, which is occupied by a membrane (the secondary tympanic membrane). The oval window communicates with the cavity of the vestibule, the round window with the scala tympani of the cochlea.—Extending backward and then downward, is a ridge-like swelling which is the outer wall of the *canal for the facial nerve* (aquæductus Fallopii). Its walls are thin, and inflammation may extend by continuity of structure directly from the middle ear to the facial nerve.—As an appendage to this descending portion of the canal is a small hollow process directed upward, known as the *pyramid*. It gives origin to the Stapedius muscle.—In front of the promontory is the beginning of the *tube for the Tensor Tympani muscle* (semicanalis). This is six lines long, and extends forward and downward toward the orifice of the Eustachian tube.

Under the tube for the Tensor Tympani, Luschka calls attention to a small portion of the carotid canal, which is here so thin at times as to permit, through ulcerative process, the occurrence of hemorrhage into the middle ear.—Von Tröltsch describes a point between the oval window and the facial canal, which answers to the horizontal semicircular canal.

The outer wall.—The outer wall is smaller than the inner, and is, except at the position of the tympanic membrane, occupied by the thin margin of the tympanic ring and the squama. In front is the glenoid fissure, which receives the slender process of the malleus and the anterior malleal ligament. Near this again is the minute opening, known as the canal of Huguier, for the chorda tympani nerve.

Fig. 140.



A diagrammatic representation of the inner wall of the tympanic chamber. *a*, promontory; *b*, oval window; *c*, round window; *d*, nerve-grooves on the promontory; *e*, pyramid; *f*, prominence of aqueduct of Fallopius; *g*, openings of mastoid cells; *h*, tube of tensor tympani; *i*, osseous part of Eustachian tube; *k*, internal carotid artery; *l*, facial nerve.

The upper wall.—The upper wall (tegmen tympani) is thin, and is derived from the petrous portion of the temporal bone. It is frequently perforated by one or more minute openings. The lining membrane of the chamber comes in contact with the dura mater of the middle cerebral fossa at these points.

The lower wall.—The lower wall, the result of the convergence of the outer and inner walls, is but little else than a groove, and answers in position to the jugular fossa. Rarely the floor, like the roof, is defective.

The posterior wall.—The posterior wall is roughened. At its upper portion it presents an opening for communication with the mastoid cells.

The anterior wall.—The anterior wall is narrow, and, like the preceding, is incomplete. The Eustachian tube begins at its junction with the inner surface. A short distance above this opening is the position of the grooved canal for the Tensor Tympani muscle.

The tympanum is supplied by the tympanic or Jacobson's nerve, and by branches from the otic ganglion of the fifth nerve.

The mucous membrane is thin, delicate, and firmly associated with the bones. For the most part the epithelium is tessellated, but may be ciliated.

Bloodvessels.—The *arteries* are derived from a branch of the internal maxillary and the stylo-mastoid branch of the posterior auricular, which goes to the posterior part of the cavities and to the mastoid cells; a small twig supplies the malleus; a twig from the middle meningeal passes through the roof of the

chamber. The *veins* are tributary to the temporal vein in great part. The middle meningeal and pharyngeal veins, however, receive some of the blood. Two minute veins run parallel to the manubrium.

Remarks.—The internal carotid artery may ulcerate into the middle ear through a carious condition of the carotid canal, and fatal hemorrhage ensue.[1] Toynbee[2] describes a case of the same lesion in which death followed on the eleventh day after the first appearance of the hemorrhage.

The floor of the middle ear is contiguous with the internal jugular vein. In consequence of the extreme variability of the thickness of this floor, it should always be borne in mind, in clinical studies of the ear, that inflammation in the tympanic chamber can be transmitted to the internal jugular vein. The lateral sinus may be involved by the encroachment of diseased action to the sigmoid groove through the walls of the mastoid cells.

The tegmen tympani or roof of the tympanum, while at all times thin, is, as above mentioned, often incomplete. Hyrtl has especially described these defects, and has directed attention to the contiguity of the dura mater and mucous membrane at such points. The student is cautioned against confounding these openings with the lesions of caries. It has been suggested by Gruber,[3] that forced inflation of the middle ear in the condition just named actually may induce submeningeal emphysema.

In the fœtus the cavity of the tympanum contains no air. The mucous membrane is thick, especially that upon the inner wall, and extends like a thick cushion to the smooth inner surface of the tympanic membrane. It is in every way probable that the band-like processes described by Urbantschitsch[4] as passing from the vertical and horizontal limbs of the incus to the walls of the tympanum, as well as one which stretches from the tendon of the Tensor Tympani to the tympanic wall, are remains of this prenatal connective tissue. In dissection of the ear, more particularly, care should be taken to distinguish these structures from morbid products.

The non-compact character of the osseous tissue to the outer side of the head of the malleus enables abscesses, originating in the tympanic chamber, to develop in the upper part of the meatus, and involve the outer ear without giving signs of their presence by any change in the tympanic membrane.

[1] N. Y. Med. Journ., 1874, xix. 38.

[2] Med. Chir. Trans , xliii. 217.

[3] Œstr. Zeitsch. für Prakt. Heilkunde, 1864, 54.

[4] Urbantschitsch, Roy. Acad. of Sci., Vienna, Jan. 1873.

Several cases have been recorded in which caries involved the horizontal semicircular canal, so that products of inflammation passed out of the cavity of the tympanum into the vestibule, and thence by the cribriform bony lamellæ to the internal auditory meatus. Pus may also enter the labyrinth by the oval or by the round window in destructive inflammation of the tympanic cavity.

Perhaps the most frequent of all the lesions of the middle ear, creating disturbance in venous, arterial, or nerve-trunks in its immediate neighborhood, is that of the involvement of the tympanic wall of the facial canal. Many phases of facial palsy follow interference with this passage and its contents through aural catarrh and necrosis. (See also Facial Nerve, p. 532.)

The quantity of mucus normally present in the middle ear is very small. It doubtless tends to gravitate to the floor, and there accumulates until it can reach the level of the orifice of the Eustachian tube, when it insensibly drains into the pharynx. After death the groove in the floor of the Eustachian tube is thus found occupied with mucus and desquamated ciliated epithelial cells. When the mucus is abnormally abundant, it obliterates the chamber of the tympanum as an air-chamber. Its physiological value being thus destroyed, morbid sensations of a variety of kinds follow. If the fluid be evacuated, as usually occurs by rupture of the tympanic membrane, the normal functions of the parts are restored. But if any portion of it remains at a higher level than the orifice of the Eustachian tube, the ossicles become impeded in their action, and in the event of the mucus becoming inspissated upon them, deafness may ensue.—The motions of an abnormal quantity of mucus in the tympanic chamber, dependent on inflation of the chamber, may be studied in cases of unusually translucent membranes.

In some cases of suspected fracture of the base of the skull, in which escape of a serous fluid from the middle ear was conspicuous, Prescott Hewett[1] ascertained that the fluid did not come from the membranes of the brain, but was doubtless derived from the mucous lining of the middle ear. Such cases tend to show not only that the presence of such a sign is not necessarily characteristic of fracture, but that the mucous membrane of the middle ear is capable of throwing off under certain conditions large quantities of a watery fluid.

[1] Holmes's Syst. of Surg., ii. 133; also H. Gray, Trans. Path. Soc. Lond., vi. 22.

THE MASTOID CELLS.

The Mastoid Cells are irregular interspaces in the mastoid portion of the temporal bone, communicating with the cavity of the tympanum. They form two sets; an upper or horizontal, and a lower and more irregular set. The upper are constant at all ages, but the lower are dependent upon the development of the mastoid process. Both are lined with a thin muco-periosteum, bearing flat epithelium cells, and are without glands.

Not infrequently the inner wall of the mastoid portion of the temporal bone is deficient at one or more places of small extent, corresponding to the situation of the floor of the lateral sinus, thus permitting the dura mater and mucous lining of the mastoid cells to come in contact.

REMARKS.—The great ease with which inflammation of the middle ear may in some cases extend to the membrane of the brain is explained by the direct relation of the structures.

In the same way attenuation or other impairment of the outer wall of the mastoid portion will often cause emphysema of the submeningeal connective tissue to follow slight injury.[1]

It is highly probable that the venous hemorrhage, which sometimes occurs from the outer ear, after blows upon the occiput, comes from the lateral sinus, and reaches the middle ear by fracture of the bone about the mastoid cells.

THE EUSTACHIAN TUBE.

The Eustachian Tube (figs. 2 and 5, Plate XCVII., fig. 4, Plate XCVIII.) is the passage between the pharynx and the tympanic chamber. It passes outward and a little upward and backward, and measures from eighteen to twenty lines in length. The tube is divided into two portions: the osseous and the cartilaginous. The line of junction of the two portions is slightly angulated.—The *osseous portion* is inclosed between the pars tympanica in front, the anterior wall of the carotid canal behind, and the *tegmen tympani* and the groove for the Tensor Tympani muscle above. It is fourteen lines in length, two lines in diameter, and represents one-fourth to one-third the entire length of the tube. It begins by a sub-elliptical orifice at the antero-inferior portion of the tympanic chamber, and terminates abruptly in a spinous process opposite to or a little in advance of the spinous process of the sphenoid bone.—The *membranous portion* is about an inch in length, and lies in a groove formed between the anterior wall of the carotid canal on the one side, and the posterior border of the horizontal portion of the great wing of the sphenoid bone on the other. Between these two portions is the sphenoido-petrosal fissure. The groove terminates opposite the posterior free edge of the inner plate of the pterygoid process. The membranous portion is held in position by dense fibrous tissue, which is continuous with that lying in the sphenoido-petrosal fissure and elsewhere at the base of the skull.[1] The essential feature in this portion of the tube is its *cartilage.* This is a sub-involuted plate (tubal cartilage), composed for the most part of pure hyaline cartilage. It is narrow at its junction with the bony portion, but gradually increases in size toward the pharyngeal end. The cartilaginous portion is from this peculiarity much wider toward the pharynx than toward the tympanum, and has received the name of the *salpinx* or *trumpet.* At its tympanic extremity, the cartilage lies for the most part upon the sphenoidal side of the groove, but through the greater portion of its course it is related to the carotid side. It is curved above to form the roof of the passage, and is thence abruptly deflected a short distance along the sphenoidal side, where it terminates. From this fact the cartilage is often called the *hook cartilage.* The floor of the tube and the remaining portion of the sphenoidal boundary are membranous. They are, however, strengthened at the pharyngeal end by the Tensor Palati and Levator Palati muscles. From the intimate relation of the above muscles with the tube, Rüdinger proposes to call this the *muscular portion.*

Occasionally the rounded end of the inferior turbinated bone extends to the opening of the tube so as to cover it. In the child the tube is horizontal, the osseous part is comparatively long, the isthmus small, and the pharyngeal orifice large.

The *mucous membrane of the tube* is separated from the cartilage by a thin layer of connective tissue, which gradually becomes thicker toward the pharynx. The tube is almost completely without glands toward the tympanic end, but is thick, cushiony, and richly supplied with racemose glands toward the pharyngeal end. The epithelium is throughout ciliated, and the movements of the cilia are so directed that the tendency is from the tympanic chamber toward the

[1] Hyrtl, Sitzungsberichte der Kais. Akad., 1858, 252.

[1] The tube may be described as having a tympanic (*i. e.*, outer), a pharyngeal (inner), a carotid (posterior), and a sphenoidal (anterior) portion.

pharynx. At the muscular portion of the tube one or two foliated elevations are found which project into the canal. These are best seen in transverse sections studied under low powers of the microscope.

The osseous and cartilaginous portions of the tube, when at rest, exhibit a marked difference in the shape of the lumen. The bony portion is subrounded and fixed, while the cartilaginous is slit-like, and its cross section has a sigmoid form with the sides almost contiguous. The height of the pharyngeal orifice is about three and a half lines (Henle). The slightly contracted portion between the cartilaginous and osseous portions is called the *isthmus* of the Eustachian tube, and measures but one line in diameter. According to Dr. E. Cutter,[1] the isthmus may be absent in the aged.

Bloodvessels.—Twigs are received from the ascending pharyngeal artery, as well as a petrosal branch of the middle meningeal. A small twig also comes from the stylo-mastoid artery.

Nerves.—These are derived from the fifth and seventh cranial nerves, and from the glosso-pharyngeal nerve through a twig from its tympanic branch.

A lymphatic network is found at the pharyngeal orifice which is continuous with the lymphatic system of the naso-pharynx.

The lower end of the hook cartilage lying at the floor of the bony sulcus is more or less irregularly incised. Vascular tufts of peri-chondrial connective tissue may penetrate the substance of the cartilage here and there.

Structure.—While the cartilage is of the hyaline variety, examples of fibro-cartilaginous tissue are met with at various places, especially in the neighborhood of the borders.

The pharyngeal orifice of the Eustachian tube is commonly at the upper and outer part of the posterior nares. It may, however, be opposite the middle and sometimes even the lower part.

The Eustachian tube is probably open at all times; that is to say, air can effect entrance through the upper portion of the lumen of the Eustachian tube, even when it is at rest. The degree of patulency of the pharyngeal end is determined by the Levator Palati, Tensor Palati, and Palati-Pharyngeus muscles. (See p. 259.)

The value of the position of the isthmus to the physician is made evident when it is remembered how small a quantity of mucus would be sufficient to plug up the opening. Upon such obstructions ensue disturbances of hearing, noises in the ear, etc.

[1] Am. Journ. Med. Sci., April, 1872, p. 359.

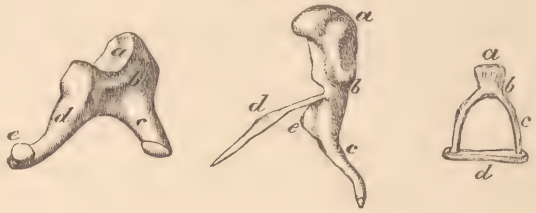
THE OSSICLES.

The Ossicles (ossiculi auditis) (figs. 2 and 3, Plate XCVII., fig. 4, Plate XCVIII.) constitute the chain of little bones which extend across the middle ear.

The ossicles are three in number—

The Malleus.
The Incus.
The Stapes.

Fig. 141.



The three Ossicles of the Tympanum: the central bone is the Malleus, the left-hand bone the Incus, and the right-hand bone the Stapes.

Malleus: *a*, head; *b*, neck; *c*, handle; *d*, long, and *e*, short process. Incus: *a*, head; *b*, body; *c*, upper process; *d*, lower process; *e*, lenticular process. Stapes: *a*, head; *b*, neck; *c*, crus; *d*, base.

THE MALLEUS. The Malleus (the hammer or the mallet) is the most anterior and exterior of the ossicles. It lies between the tympanic membrane and the incus. It is of a club-shaped figure, the larger end being upward. The bone presents for examination a *head*, a *neck*, a *handle*, and two *processes*. The *head* is a smooth rounded enlargement of the bone, which is lodged in the upper portion of the chamber of the middle ear. It lies entirely above the tympanic membrane, and constitutes nearly one-half of the entire malleus. The head is convex in form, and is free from attachment on all its surfaces excepting above the lower half of the inner surface, which is furnished with an elliptical articular facet for the body of the incus. The facet is two or three times as long as it is wide, has its longest length obliquely placed to the axis of the malleus, and is furnished with swollen borders.

The *neck* is a constricted portion of the malleus, which lies between the head and the handle. It is somewhat flattened from within outward, and lies just above the upper margin of the tympanic membrane. The chorda tympani lies to its inner side.

The *handle* (manubrium) is a scythe-like extension of the malleus. It maintains a direction downward, with a slight inclination inward and forward. The handle is compressed from before backward, except toward the free end, where it is compressed from within outward. It is received within the middle layer of the tympanic membrane, and causes an elevation to appear upon the outer surface of the mem-

brane, which forms with the short process a conspicuous feature at the bottom of the external auditory meatus.

The *processes of the malleus* are two in number, the *long* and the *short*. The *long process* (process of Foli) arises from the base of the handle at its anterior aspect. It is directed at first forward, and afterwards downward and forward as a thin, flat pointed blade which is finally received within the glenoid fissure. The *short process* is a small but conspicuous projection from the anterior aspect of the base of the handle. It is directed outward, and is engaged in the tympanic membrane, where it forms a whitish elevation already described.

The long process represents the primordial axis of the malleus, and in the fœtus is continuous with Meckel's cartilage. In childhood it lies free in the glenoid fissure, but is liable to be mutilated in specimens obtained from adult subjects from its disposition to become anchylosed to the sides of the fissure.

The Incus. The Incus (anvil) is situated in the chain of ossicles between the malleus and the stapes. It is composed of a body and two processes. The whole figure bears a resemblance to a bicuspid tooth—the body corresponding to the crown of the tooth, and the processes to the diverging roots. The body and the upper of the two processes lie above the upper margin of the tympanic membrane. The *body* is compressed from within outward, and gradually diminishes in volume from before backward. It presents in front a subrounded saddle-shaped facet for articulation with the malleus. The *upper process* (short, posterior, or horizontal process) is nearly horizontal, and is directed backward. The upper border is inclined, while the lower is straight, and abruptly terminates where it lies against the posterior wall of the tympanic chamber above the position of the opening of communication with the mastoid cells. The *lower process* (stapedial crus, long process) descends vertically in a line nearly parallel to the handle of the malleus. It tapers gradually toward its free end, where it is abruptly deflected inward to terminate in the *lenticular process* (lenticulare Sylvii, os orbiculare) by means of which the incus articulates with the stapes. The lenticular process is distinguished by an annular constriction at its base. In early life the lenticular process is a separate ossicle.

The Stapes.—The stapes (the stirrup) is lodged between the incus and the oval window. It presents a head, a base, and two crura. The head is a rounded projection placed at the junction of the crura, and presents a concave surface for the lenticular process. The base is kidney-shaped, and answers to the outline of the oval window. It is nearly straight on one side, and slightly convex on the other. The anterior crus is straight and shorter than the posterior. The space between the crura is marked by a faint groove for the reception of a thin membrane. The lenticular ossicle may become anchylosed to the stapes instead of to the incus. The borders of the base of the stapes are covered with hyaline cartilage.[1]

Variations.—The malleus may have a broad, foliated handle and a short neck. A scale-like ossification in the tympanic membrane may be attached to the malleus. The incus frequently exhibits a notch on the lower border of the upper process. The lower process may be inclined toward the inner wall of the tympanum, and even fixed to it. The crura of the stapes may scarcely at all diverge, and the space between them be narrowed. The tendon of the Stapedius muscle may become ossified and anchylosed to the stapes. —The ossicles are always as large in the new-born infant as in the adult, and in some instances are even somewhat larger.

The Ligaments of the Ossicles. The malleus is fixed by three ligaments.

The Anterior Ligament.
The Superior Ligament.
The External Ligament.

The Anterior Ligament extends from the long process to the tympanic bone. This ligament was formerly thought to be a muscle, and received the name of Laxator Tympani.

The Superior Ligament (axial ligament) passes from the head of the malleus to the temporal bone.

The External Ligament extends from the neck of the malleus to the temporal bone. Under the head of the Posterior Ligament, Helmholtz describes a fascicle of the last-named ligament.

The incus is supported by a single ligament which extends from the body of the bone, near the articular facet with the malleus, to the roof of the tympanum.

The Muscles of the Middle Ear.

The Muscles of the Middle Ear are—

The Tensor Tympani.
The Stapedius.

THE TENSOR TYMPANI.

The Tensor Tympani arises from the petrous portion of the temporal bone, from the sphenoid bone, and

[1] *Note to the description of the ossicles.* In the above description, the ossicles are assumed to be in relation to the skull rather than to the membrane of the tympanum. A direction toward the face is in "front;" towards the occiput is "behind;" toward the vertex is "above;" toward the base "below;" toward the tympanic membrane is "without;" toward the promontory "within," etc.

from the cartilaginous portion of the Eustachian tube. It is lodged in the semicanalis, becomes tendinous as it passes around the tympanic edge of the partition between the semicanalis and the Eustachian tube (processus cochleariformis), and is inserted by a delicate tendon into the base of the handle of the malleus, upon the inner (tympanic) side of the bone, immediately below the base of the short process.

Function.—To rotate the malleus inward and indirectly to make tense the tympanic membrane.

The length of the tendon from the end of the semicanalis to its insertion on the hammer Weber[1] gives at two and a fourth mm., and its direction as being somewhat forward and downward. Its insertion on the malleus is three and three-fourths mm. from the end of the manubrium, and four and a half mm. below the top of the malleus.

The Tensor Tympani is surrounded throughout its entire course by a fibrous sheath arising from the roof of the tubal cartilage, and from the edge of the fibro-cartilage basilaris, and passing along the entire muscle. The mucous membrane of the chamber does not come in contact with the muscle. Even here its sheath is continuous with that from the osseous portion.

THE STAPEDIUS.

The Stapedius is a small muscle which arises from the cavity within the pyramid. After escaping from this cavity it turns at nearly a right angle, and is inserted upon the anterior side of the neck of the stapes.

According to Rüdinger, the tendon sends a slip to the lenticular process and to the capsule. The same writer describes a small fascicle (*Fixator Baseos Stapedis*) which passes from the upper margin of the oval window to the stapes.

Function.—The Stapedius assists in holding the stapes in position, and draws the head of the bone backward and slightly downward, and relaxes the pressure on the oval window. It thus acts as a check to the inward pressure of the stapes against the labyrinth. The same act of contraction aids in relaxing the tympanic membrane; the muscle thus acts as an antagonizer to the action of the Tensor Tympani.

Nerve Supply.—The Tensor Tympani secures nerve-fibres from the otic ganglion.

The Stapedius is supplied by the facial nerve.

REMARKS.—The Tensor Tympani muscle undergoes contracture in some forms of chronic deafness, and it has been proposed to divide the tendon as it lies near the neck of the malleus.

The Stapedius muscle is sometimes paralyzed in facial palsy.

THE INNER EAR.

The Inner Ear (the labyrinth) is the essential portion of the organ of hearing. It is situated within the petrous portion of the temporal bone, between the internal auditory meatus and the chamber of the tympanum. It is composed of a membranous labyrinth and a bony labyrinth.

The *membranous labyrinth* is a chamber of irregular form which contains a fluid and particles of carbonate of lime, known as *otoliths*. The chamber receives the terminal filaments of the acoustic nerve.

The *bony labyrinth* is the osseous envelope of the membranous labyrinth.

THE BONY LABYRINTH.

The membranous labyrinth is encased in a bony framework which corresponds to it in form. The bony labyrinth is surrounded by a thin cancellated layer of bone, with the exception of the outer surface which lies upon the inner wall of the tympanic chamber, where it is covered with thin mucous membrane. The cancellated tissue is best developed in the infant, while in the adult it becomes relatively compact. As a result of this disposition, the labyrinth is more difficult to remove from the skull in the adult than in the young subject.

The bony labyrinth (figs. 2, 3, 4, Plate XCVIII.) is composed of—

The Vestibule.
The Semicircular Canals.
The Cochlea.

[1] Monatschr. für Ohrenheilkunde, Oct. 1872.

EXPLANATION OF PLATE XCVIII.

Fig. 1. View of the posterior nares and the relative parts, as seen by reflected light.

Fig. 2. The bony labyrinth in position, as seen from behind.

Fig. 3. The bony labyrinth in position, as seen from above.

Fig. 4. A frontal (transverse vertical) section of the temporal bone with the Eustachian tube in position. Designed more particularly to display the Aquæductus Fallopii (facial canal) and the tympanic chamber.

Fig 1



Fig. 2.

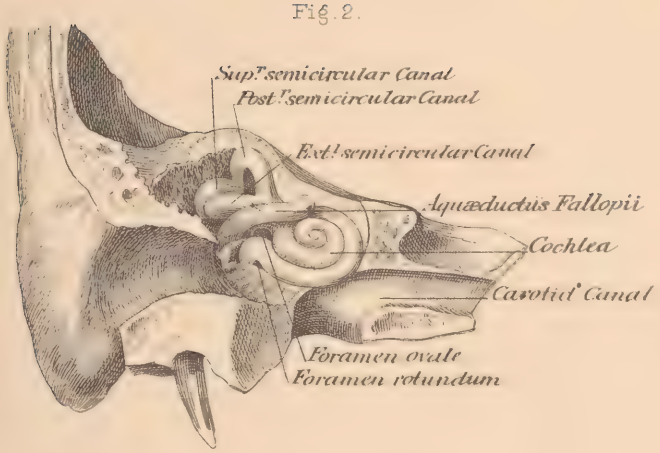


Fig. 3

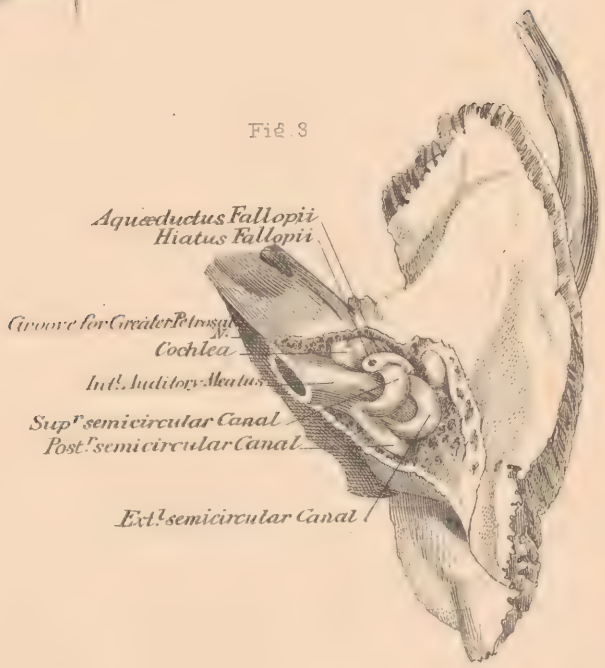
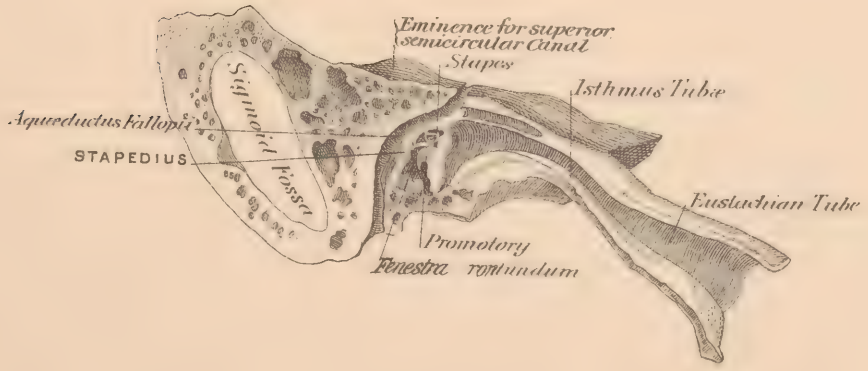


Fig. 4.



T. Sinclair & Son Lith.

THE VESTIBULE.

The Vestibule is a chamber of an irregularly oval shape, and slightly flattened from within outward. It is designed to accommodate the utricle and the saccule, and communicates with the semicircular canals posteriorly and the cochlea anteriorly. The vestibule measures about one-fifth of an inch in diameter.

The inner wall of the vestibule is marked by a crest (crista vestibuli), which serves as the intermediate space between the depression for the utricle (fovea hemielliptica), which lies behind the crest, and the depression of the saccule (fovea hemispherica), which lies in front of it.

The vestibule communicates on its outer wall with the middle ear by the foramen ovale. It in addition receives the openings of semicircular canals, the foramina for the nerves to the membranous labyrinth, and the opening of the aquæductus vestibuli.

The *openings of the semicircular canals* embrace the three ampullæ, and the orifices of both ends of the horizontal canal, as well as the orifice of the canal resulting from the union of the vertical transverse and vertical longitudinal semicircular canals.

The *openings of nerves.* The nerves for the membranous labyrinth enter the inner wall of the bony labyrinth, through minute openings which are arranged as follows:—

First group (macula cribrosa superior) situated at the pyramidal eminence; second group (macula cribrosa media) situated below the centre of the fovea hemielliptica; third group (macula cribrosa inferior) situated near the junction of the inner and the posterior walls with the floor, and within the ampulla of the vertical longitudinal semicircular canal.

To these groups may be added a fourth (macula cribrosa quarta, Reichert), which lies near the anterior border of the fovea hemispherica.

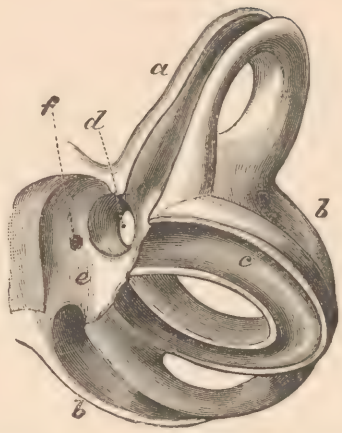
The opening for the aquæductus vestibuli lies near the ampulla of the external semicircular canal. It conveys lymph from the subarachnoid space to the interior of the vestibule.

The Aquæductus Vestibuli. The aquæductus vestibuli is a small canal leading backward to the posterior surface of the petrous portion of the temporal bone. In the infant it is much larger than in the adult, and appears as a shallow chink.

THE SEMICIRCULAR CANALS.

The Semicircular Canals are three C-shaped tubes which open into the vestibule. Each tube is slightly compressed laterally, and presents a diameter of one-twentieth of an inch.

Fig. 142.



a, vertical transverse; *b*, horizontal; *c*, vertical longitudinal; *d*, common opening of the two vertical canals; *e*, part of the vestibular cavity; *f*, opening of the aqueduct of the vestibule.

Each tube departs from a plane of a true arch. One of the extremities of each canal is enlarged before it enters the vestibule constituting the so-called *ampulla.*

The canals are named from their respective positions as follows:—

The Vertical transverse.
The Vertical longitudinal.
The Horizontal.[1]

(1) The *vertical transverse* canal (superior, frontal) is the largest of the three. It forms a conspicuous swelling upon the anterior aspect of the petrous portion of the temporal bone. Its anterior part forms an ampulla; its posterior joins the anterior part of the succeeding canal.

(2) The *vertical longitudinal* canal (posterior, sagittal) extends parallel to the axis of the petrous portion of the temporal bone. It is nearly circular in form, and is the lowest in position of the three. An ampulla is developed upon its posterior extremity, the anterior joining the vertical transverse canal.

(3) The *horizontal* canal (external) is the shortest of the three. It extends obliquely from without downward. Its anterior extremity forms an ampulla, and opens near the outer wall of the vestibule.

[1] Respecting the synonymy of these names, it may be said that the terms "vertical" and "horizontal" indicate the relations of the canals to the plane of the base of the skull; the terms "transverse" and "longitudinal" to the axis of the petrous portion of the temporal bone; the terms "superior" and "inferior" refer to their position to the plane of the base of the skull; and the terms "anterior" and "posterior" to their position in connection with the longitudinal axis of the skull. If the axis of the auditory nerve were taken as a guide, it would be found that the horizontal semicircular canal would be transverse to this axis, and at the same time external to it.

THE COCHLEA.

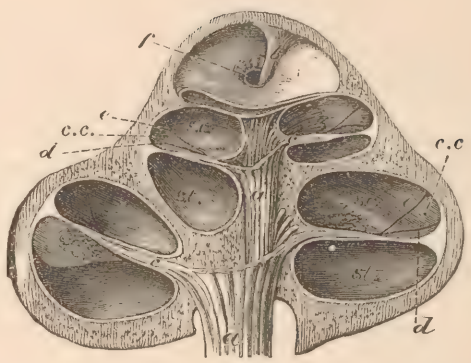
The Cochlea, so called from the resemblance it bears to a snail's shell, is that portion of the bony labyrinth which receives the cochlear canal. The plan of the cochlea is that of a bony tube, turned two and a half times upon itself, and rapidly diminishing in calibre from below upward. The whorls are directed from the left to the right in the right ear, and from the right to the left in the left ear. The basal structures of the cochlea are often included in the term vestibular portion. The apex of the cochlea is called the *cupola*.

The cochlea is directed forward, outward, and downward from the anterior portion of the vestibule, the base of the conic figure presenting toward the internal auditory canal. The cochlea communicates with the vestibule by a large opening (*apertura baseos cochlearis*), and with the chamber of the tympanum by means of the round window. The first whorl constitutes a portion of the inner wall of the chamber of the tympanum, and forms there a conspicuous eminence—the *promontory*. In front of the cupola lies the carotid canal. The cochlea lies in front of the superior petrosal sinus, and near the canal for the Tensor Tympani muscle.

The cochlea is from two to two and a half lines long by three to three and a half in width. The whole tube is about one-and-a-half inch long. Its axis measures fifteen lines in length, while its base is four lines in width.

The cochlear tube circumscribes a small portion of the petrous portion of the temporal bone termed the *modiolus* (columella cochleæ), which extends from the base of the cochlea to the level of the second whorl. The modiolus rests upon the bottom of the internal meatus at the spiral tract.—The cochlea also permits a dense lamina of the petrous bone to be received between the first and second whorls, whence it follows the spiral turns of the tube to terminate within the apex. This forms the wall of a small space, which, in consequence of its funnel-like shape, is called the *infundibulum*. The modiolus communicates with the infundibulum by means of a small canal (*canalis centralis modioli*), which extends the entire length of the modiolus. The modiolus and the infundibulum may be compared to two cones touching at their tops: the former is cancellated petrous bone carried within the cochlea at its base; the latter is the termination of a lamina of petrous bone carried into the cochlea from its side.

Fig. 143.



a, axis with its canals; *b*, infundibulum or enlarged upper end of the axis; *c*, septum of the cochlea; *d*, membrane of Corti; *e*, membrane of Reissner; *f*, hiatus or helicotrema; *s t*, scala tympani; *s v*, scala vestibuli; *c c*, cochlear canal.

The parts above described may be held as related to a hypothetical axis or line which extends from the centre to the base of the cochlea, along the modiolus to the cupola. Such an axis as is produced within and beyond the infundibulum lies to the inner side of the last whorl of the cochlea. The *true* axis of the cochlea is, of course, the axis of the cochlear tube itself, and is a line produced along the course of the tube at a point which answers to the junction of the osseous lamina and the membranous structure transecting the cochlear tube.

When a longitudinal section of the cochlea is made, after maceration of the petrous bone, the modiolus presents the appearance of a tapering shaft, about whose periphery extends a spiral ledge-like line, measuring about one-tenth of an inch in width, called the *lamina ossea spiralis*.

Its free edge extends about half way across the bony cochlear canal, and indicates the division of the canal into two compartments as effected by the membranous lamina in the unmacerated specimen.

The space below the conjoined laminæ receives the name of the *scala tympani*, since it terminates at the round window of the tympanum; while that above is known as the *scala vestibuli*, since it opens upon the cavity of the vestibule, where, when the membranous labyrinth is in position, it communicates with the saccule.

It will be observed that the *scalæ* do not exist in the macerated specimen, since the bony cochlear canal is not completely divided by the bony spiral lamina.

The plan as above given is modified toward the cupola as follows: The bony lamina terminates in a small hook-like process which is called the *hamulus*. The opening of continuity between the scalæ is called the *helicotrema*.

Structure.—The bony lamina consists of a compact tissue at its free edge, as well as upon the upper and lower surfaces; but within it is porous. It is continuous with the similar structure of the modiolus, and is distinguished from it by numbers of minute anastomosing canals, which transmit the cochlear nerves and bloodvessels to the membranous cochlea. Winding spirally around the modiolus, beneath the lamina spiralis, is a small canal called the canalis spiralis modioli (spiral canal of Rosenthal).

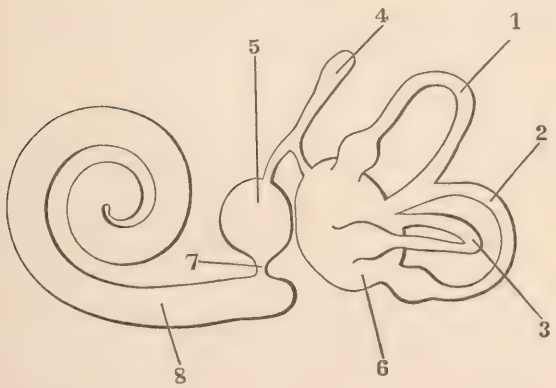
The Aquæductus Cochleæ. This is a small canal leading from the cochlea at the tympanic scala to the base of the skull. It is of a triangular shape, and is situated upon the ridge which lies between the carotid canal and the jugular fossa. It conveys the perilymph from the cochlear scalæ to the subarachnoid space.

THE MEMBRANOUS LABYRINTH.

The Membranous Labyrinth is the true organ of hearing, and to it the terminal filaments of the auditory nerve are distributed. It lies within the bony labyrinth, to which it corresponds quite closely in form, though it does not completely fill the various cavities of this structure, being separated therefrom for the most part by a serous fluid called the *perilymph*.

The membranous and bony labyrinths are in contact at the points where the auditory nerve enters the former, and along the convex border of the cochlea.

Fig. 144.



Diagrammatic outline of the membranous labyrinth.

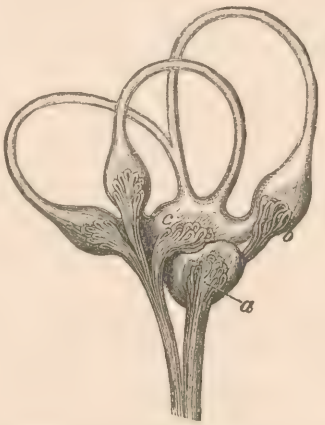
1. Vertical transverse s. c. canal; 2. Vertical longitudinal s. c. canal; 3. Horizontal s. c. canal; 4. Recessus labyrinthi; 5. Saccule; 6. Utricle; 7. Canalis reuniens; 8. Canal of the cochlea.

The membranous labyrinth[1] consists of six chief parts—

The Utricle.
The Saccule.
The Semicircular Canals.
The Canal of the Cochlea.
The Canalis Reuniens.
Recessus Labyrinthi.

The membranous labyrinth is composed of a central portion which answers in position to the vestibule, and is divided into a posterior chamber—the *utricle*—lodged in the fovea hemielliptica and the remaining portion of the vestibule not occupied by the saccule,[1] and an anterior chamber—the *saccule*—which is lodged in the fovea hemispherica. The utricle is a part of the system of the semicircular canals, and the saccule is a part of the system of the cochlea. The utricle, in a marked degree, and the saccule, in a slight degree, are slightly compressed from before backward. Both the utricle and the saccule contain a circumscribed collection of crystals of carbonate of lime (otoliths, otoconia) which is fixed to the inner wall. Each semicircular canal expands into a flask-shaped chamber toward the *ampulla*, which corresponds in form and position to the ampulla already described in the account of the bony labyrinth. The utricle, saccule, and the ampullæ are united to the periosteum of the bony labyrinth at points which answer to the entrance of nerve-filaments.

Fig. 145.



The membranous labyrinth and the distribution of the auditory nerve (diagrammatic). *a*, branch to saccule; *b*, branch to ampulla of the vertical longitudinal semicircular canal; *c*, branch to utricle.

Each of the semicircular canals exhibits on transverse section an oval lumen, and is occupied by three layers—an outer, a middle, and an inner.

The *outer layer* (membranous layer) is fibrous, and, as already stated, is fixed to the periosteum at certain points of the bony labyrinth.

[1] The term membranous labyrinth is used by some German writers (see Rudinger and Waldeyer, Stricker's Handbuch) as distinct from the cochlea, which is separately treated.

[1] The utricle is represented by many writers as confined to the fovea hemielliptica. The author has followed Henle (see fig. 144) in the above description.

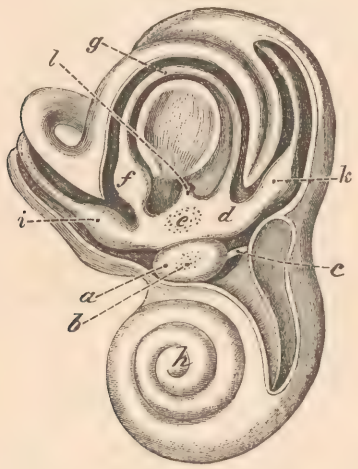
The *middle layer* (lamina propria) is structureless, and forms the bulk of the wall of the canal. It is thinnest opposite the points of fixation to the periosteum.

The *inner layer* (epithelial layer) is tessellated, with an occasional papillar aggregation. Hence the section of the layer presents a wavy appearance.

In the ampullæ, the posterior or the fixed wall sends inward a partition-like projection (crista acustica), which answers to the place of termination of the nerve-filaments.

The structure of the utricle and of the saccule in no wise differs from that of the semicircular canals and of the ampullæ.

Fig. 146.



A diagrammatic plan of the labyrinth. *a*, saccule; *b*, entrance of nerve-filaments to saccule; *c*, aquæductus vestibuli; *d*, utricle; *e*, entrance of nerve-filaments to utricle; *f*, ampulla of horizontal semicircular canal; *h*, cupola; *i*, ampulla of the vertical transverse semicircular canal; *k*, ampulla of the vertical longitudinal semicircular canal; *l*, opening of the canal of union of the vertical longitudinal and vertical transverse semicircular canals.

CANALIS REUNIENS.

The Canalis Reuniens is a small passage connecting the saccule with the cochlear canal.

RECESSUS LABYRINTHI.

The Recessus Labyrinthi is a delicate tube which lies within the aquæductus vestibuli, and which connects with the saccule and with the utricle. It is lined with epithelium and ends blindly (saccus endolymphaticus) in the dura mater near the orifice of the aquæductus vestibuli.

The Endolymph. The endolymph is the lymph-fluid which occupies the membranous labyrinth. It fills all portions of the main central cavity, the semicircular canals, the cochlear canal and the recessus labyrinthi.

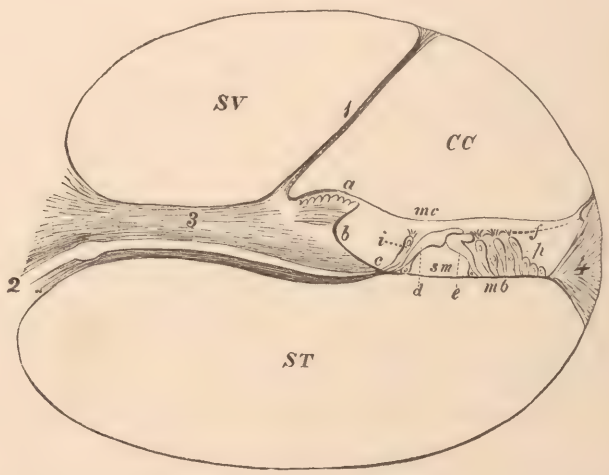
The Perilymph. The perilymph is a lymph-fluid which occupies the space between the membranous labyrinth and the walls of the bony labyrinth and the cochlear scalæ, namely, the entire cochlea with the exception of the cochlear canal. It communicates by the aquæductus cochleæ with the subarachnoid lymph-space.

THE COCHLEAR CANAL.

The anterior portion of the saccule contracts abruptly to form a small canal which has received the name of the *canalis reuniens.* It extends downward and forward, and communicates with the cochlear canal.

The Cochlear Canal (scala media, membranous cochlea, ductus cochlearis) begins by a broad opening at the lower and anterior portion of the vestibule. It at once enters the cochlea, where it lies in the space between the outer wall of the canal and the outer free edge of the lamina ossea spiralis, and aids in defining the scala, but lies on a plane above that of the lamina. As seen in a vertical section of the cochlea, the cochlear canal presents a triangular appearance; the base of the figure corresponds to the outer wall of the cochlea, the apex to the edge of the lamina ossea spiralis, the lower side to a membrane (basilar membrane) which extends horizontally outward between the lamina ossea spiralis and the outer wall of the cochlea, and the upper side to a second membrane (membrane of Reissner, membrana vestibularis) which extends obliquely upward and outward.

Fig. 147.



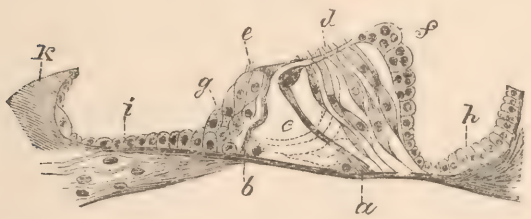
Section through one of the coils of the cochlea, showing the organ of Corti (diagrammatic); *S V*, scala vestibuli; *S T*, scala tympani; *C C*, cochlear canal; *b*, spiral groove; *d*, one of the inner rods of Corti; *e*, one of the external rods of Corti; *f*, lamina reticularis; *i*, one of the inner hair-cells; *p*, external hair-cells; *m c*, membrana tectoria; *s m*, tunnel of Corti; *m b*, membrana basilaris; 1, membrane of Reissner; 2, cochlear nerve; 3, lamina ossea spiralis; 4, position of ligamentum spirale coarsely represented.

The lamina spiralis modioli projects in the cupola over the hamulus, and thus embraces an opening, the helicotrema Breschetti, through which the *scala tympani* and *scala vestibuli* communicate.

Structure.—The structure of the cochlear canal is much more complex than is that of the other portions of the membranous labyrinth. Continuous with the lamina ossea spiralis is a membranous structure which extends across the cochlear tube, and which serves to separate the vestibular from the tympanic scala. At the inner third of the bony lamina the membrane of Reissner is attached.

The membrane is fixed to the terminal third of the vestibular surface of the bony lamina, and terminates in a thickened extremity which is called the *limbus spiralis*. Beneath the limbus and between it and the apex of the bony lamina is the *inner spiral groove*. The *basement membrane* extends from the free edge of the bony lamina horizontally across the cochlea to the outer wall of the canal, where it aids in defining the *outer spiral groove*. Resting upon the basement membrane is a layer of epithelial cells.

Fig. 148.

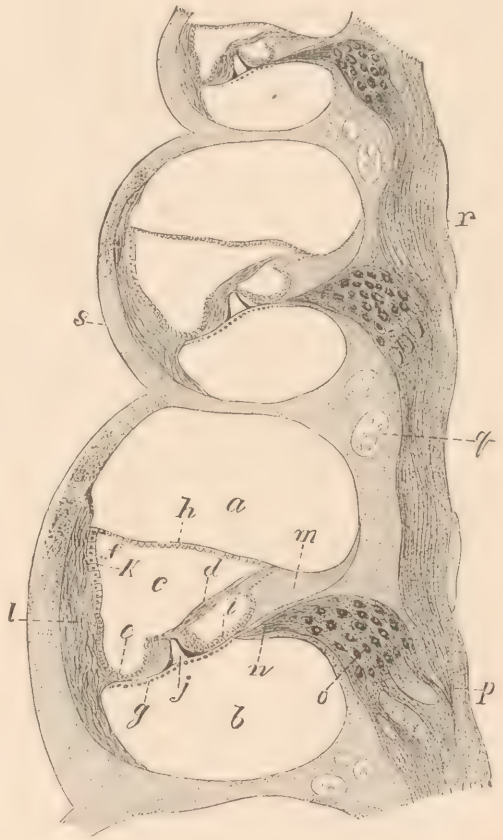


Organ of Corti of the cochlea of a Guinea-pig. *a*, outer rod or pillar of Corti; *b*, inner rod or pillar of Corti; *c*, tunnel of Corti's arch; *d*, outer hair-cells; *e*, inner hair-cell; *f*, outer supporting cells containing fat globules; *g*, inner supporting cells; *h*, cells; *i* epithelial cells lining the sulcus spiralis internus; *k*, part of crista spiralis.

The Organ of Corti. Lying upon the basement membrane, and lying a little nearer the inner than the outer spiral groove, is a delicate complex structure which has received the name of the organ of Corti. Seen in transverse section the organ of Corti resembles an arch whose sides (inner and outer) are termed the *rods of Corti*, the parts uniting the rods at their summits are termed the *roof-cells* (phalangeal cells), which compose the *reticular lamina*, and the archway defined by the rods is termed the *tunnel of Corti*. To the inner side of the inner rods lies a row of cells (cells of Deiters) surmounted by minute hairs. These cells are known as the *inner hair-cells*. To the outer side of the outer rods lie three or four rows of similar cells, which are called the *outer hair-cells*. The reticular lamina is, as the name expresses, a membrane of a delicate open network of fibres through which the hair-cells project free above the entire Cortian organ.

The entire structure is covered with a delicate and somewhat elastic membrane (the *membrana tectoria*), which extends from the limbus spiralis across and over the organ of Corti to join the epithelial cells of the basement membrane some distance beyond the outer hair-cells.

Fig. 149.



Vertical section through the cochlea of a Guinea-pig's ear, seen in the long axis of the modiolus. *a*, scala vestibuli; *b*, scala tympani; *c*, cochlear canal; *d*, membrana tectoria; *e*, cells; *f*, upper outer angle of the scala media; *g*, region of the outer hair-cells on the membrana basilaris; *h*, membrane of Reissner; *i*, epithelium lining the sulcus spiralis (internus); *j*, tunnel of Corti's arch; *k*, stria vascularis; *l*, ligamentum spirale; *m*, crista spiralis; *n*, nerve-fibres *o*, ganglion spirale; *p*, nerve-fibres in the modiolus; *q*, channels in bone containing bloodvessels; *r*, masses of bone int he modiolus; *s*, bony capsule.

Thus, to recapitulate, there exist in the organ of Corti an inner and outer series of *rods* of Corti; an inner and outer series of *hair-cells;* a series of roof-cells which constitute the *reticular lamina* placed upon the conjoined apices of the rods, and a second covering membrane to the whole organ *the tectorial membrane.*

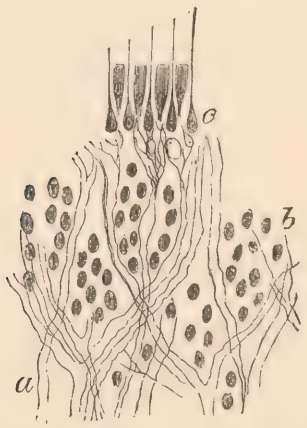
For a more minute description of this remarkable structure, the student is referred to the special memoirs of Kölliker and Waldeyer, or to a careful *résumé* of the later views in Quain's Anatomy, ninth edition.

The Nerves of the Inner Ear.—The auditory nerve, after leaving the internal auditory meatus, divides into two branches, one for the cochlea and the vertical longitudinal canal, and the other for the saccule, the utricle, and the vertical transverse and horizontal canals. The latter in turn divides into two branches: A. One of these again divides into three, which are designed (1) to supply the ampulla of the vertical transverse semicircular canal; (2) to supply the ampulla of the horizontal semicircular canal; and (3) to supply the otoliths of the utricle.—B. The other branch supplies the otoliths of the saccule, and sends the remaining bundle of filaments by a special route, viz., through a small bony passage behind the position of the foramina for the nerve of the saccule to the ampulla of the vertical longitudinal canal.

The nerve for the cochlea passes along the spiral tract to enter the modiolus. It soon divides into a great number of branches, which escape through the porous intervals between the vestibular and tympanic plates of the lamina ossea spiralis, to be received within the epithelial structure of the organ of Corti. Their ultimate destination, however, is the basement membrane beneath the organ of Corti.

The filaments for the terminal portion of the cochlear duct are not received from the side as above described, but by a number of special fibres transmitted vertically the entire length of the cochlea, through the canalis centralis modioli.

Fig. 150.



From a transverse section through the macula acustica of the utricle of the labyrinth of a Guinea-pig. *a*, medullated nerve-fibres, forming plexuses; *b*, nuclei of the membrane; *c*, sensory epithelium (diagrammatic); spindle-shaped sensory-cells possess long auditory hairs projecting between the conical epithelium cells beyond the free surface.

Just prior to their exit from the modiolus, the cochlear nerves are enriched with nerve-cells. This tract is situated within the canalis spiralis modioli already noticed.

The above account is abridged from Breschet. According to G. Retzius, the vestibular branch supplies the utricle and the ampullæ of the vertical longitudinal and the horizontal semicircular canals, while the cochlear branch supplies the cochlear canal, and the ampullæ of the vertical transverse semicircular canal.

Bloodvessels of the Inner Ear.—The *arteries* of the membranous labyrinth are derived as follows: For the semicircular canals, the utricle and saccule, the internal auditory artery or the superior cerebellar artery. Communicating branches are derived from the arterial supply of the tympanic chamber. They may also receive branches from the stylo-mastoid, from the posterior auricular, or from occasional branches of the occipital artery.

For the cochlea a number of twigs enter the modiolus and form a network occupying the interstices in the lamina ossea spiralis and the outer wall of the cochlear canal.

Remarks.—The auditory nerve may undergo atrophy either in whole or in part. This condition is probably caused by lymph-stasis, or atheromatous degeneration of the auditory artery, though it may be limited to a portion of the fibres of distribution. The parts of the cochlear nerve which supply the basal convolution of the cochlear canal may be separately involved.[1] After obliteration of the semicircular canal in animals, the cells of the cerebellar cortex undergo degeneration.[2] Peripheral disease of the nerve is thus seen to be followed by the same class of changes in the central nervous system previously known to exist in the case of the optic nerve. After destruction of the internal ear, the auditory nerve may undergo progressive fatty degeneration.[3]

Concretions of phosphate of lime may form in the neurilemma.[4] Moos[5] has found them in chronic deafness associated with subjective noises. For additional remarks see p. 617.

THE INTERNAL AUDITORY MEATUS.

The Internal Auditory Meatus extends from the posterior surface of the petrous portion of the temporal bone, toward the vestibule, to the base of the cochlea. Its direction is directly outward. It is between five and six lines long, and two lines wide.

[1] S. Moos and Steinbrügge, Archives of Otology, 1881, x. 10.

[2] Stephani and Weiss, for reference and comment see C. Spamer, Pflüger's Archiv für die gesammte Physiologie, 1879, xxi. Nos. 10 and 12.

[3] O. Weber, Pitha, and Billroth's Chirurgie.

[4] Böttcher, Virchow's Archiv, xii.

[5] See abstract in Archives of Otology, 1879, viii. 96.

The bottom of the meatus is divided into two parts by a crest (crista falciformis). Above the crest are situated two small fossæ. The anterior of these is designed for the entrance of the facial nerve into the aquæductus Fallopii. The other, the smaller of the two, receives the branch of the vestibular nerve for the utricle, the ampullæ of the vertical transverse and the horizontal semicircular canals. Below the crest are tracts for the entrance of the branches of the cochlear nerve to the modiolus, while at the posterior part of the base of the meatus are two or three minute rounded openings for the branch destined for the ampulla of the vertical longitudinal semicircular canal, and for the nerve to the saccule.

Variations of the Labyrinth.—The posterior end of the ampulla of the horizontal canal has been found dilated by Gerlach.[1] The semicircular canals may be absent either on one or both sides of the body. Defective semicircular canals imply defect of the cochlear whorls, while an abnormally formed cochlea may exist with normal semicircular canals.

The diameters of the labyrinth may be narrowed by hyperostosis.

The foramen rotundum may rarely open upon the vestibule instead of the cochlea.

Hyrtl found the aquæductus vestibuli absent, and in a second instance two passages present. Both the *aquæductus vestibuli* and the *aquæductus cochleæ* may be abnormally widened. Ibsen found the *aquæductus vestibuli* unusually large in deaf mutes.

Remarks.—The medical applications of a knowledge of the anatomy of the labyrinth and internal auditory meatus include the following:—

(*a*) The localization of diseased action in the bony labyrinth.

(*b*) The extension of disease to the labyrinth by continuity from the chamber of the tympanum.

(*c*) The relations between the degree of pressure existing in the subarachnoid lymph-space, and that in the labyrinth.

(*d*) Localization of disease in the internal auditory meatus.

(*a*) The early and complete ossification, the nourishment by means of non-anastomosing vessels, and the compact structure of the bone, are factors entering into the question of necrosis of the labyrinth. Notwithstanding such predisposing conditions idiopathic necrosis is of less frequent occurrence than caries.

The labyrinth may be involved in caries and in necrosis of the petrous portion of the temporal bone. Since such a process is commonly the sequel of chronic suppurative disease of the middle ear, those portions exposed upon the inner wall of the chamber of the tympanum most commonly suffer. Sequestra containing the basal portion of the bony cochlea or of the entire cochlea have been removed from the living subject. In less frequent instances portions of the semicircular canals and vestibule have been removed. The effect of chronic otitis media is to induce hyperostosis of the petrous portion and the mastoid portion of the temporal bone. Foci of carious degeneration are scattered throughout the mass, being more especially located upon the bony labyrinth. Hyperostosis may narrow or occlude the round window, and excite the formation of nodosities upon the inner wall of the labyrinth.

The horizontal semicircular canal and the vertical transverse semicircular canal are relatively near the facial canal, and may thus be involved in necrosis involving these portions of the labyrinth.

A. Lucæ[1] reports the removal from the external auditory canal of a necrosed fragment which was identified with the upper two-thirds of the cochlea. The patient had had vertigo and bloody purulent discharge from the ear, which symptoms disappeared after the removal of the fragment.

Embolism of the auditory artery may cause the death of the entire labyrinth.

(*b*) In addition to disease of the tympanic chamber extending to the labyrinth through the general bony investment of the petrous bone, the round and oval windows afford means of direct continuity between the two portions of the ear. The oval window, closed as it is by the stapes in normal condition, would ordinarily separate the middle from the inner ear, but it should not be forgotten that the stapes may itself be absent. The most frequent means of communication is by the round window, the single factor of interference being the occluding membrane.

(*c*) Since the inner ear, by means of its lymph communicates with the subarachnoid space (through the internal auditory meatus, and at the base of the latter passage with the perilymph), the pressure in the labyrinth is in a measure under the control of the fluid in that space. In some forms of deafness, attributed to the increase of this pressure, it may exist within the cranium independently of interference with the auditory nerve.

In cerebro-spinal meningitis, the inflammatory state

[1] Physico-Med. Soc. of Erlangen, Nov. 10, 1879.

[1] Archiv für Ohrenheilkunde, 1875, iv. 4.

of the subarachnoidal membrane may be transmitted by continuity to the labyrinth. A. Lucæ[1] dissected the ear of a subject dying from the above disease, and found the labyrinth in a state of suppurative inflammation, but with no involvement of the nerve-trunks.—J. W. Ogle[2] attributes the implication of the base of the brain, in some forms of suppuration of the inner ear, to a morbific element extending from the ear to the arachnoid membrane by the prolongation of that structure along the internal auditory meatus.

(*d*) Tumors have been detected protruding within the internal meatus. Clots may form within the passage, and syphilitic growths have been here located.[3]

Concluding Remarks on the Middle Ear.[4]

The Tympanic Chamber.—Meckel[5] describes a space between the triangular eminence, the promontory, and the oval window, which he named the sinus tympani. H. Steinbrügge[6] describes the sinus as follows: An excavation on wall of labyrinth beneath the canal for the facial nerve to a point near the ampullar end of the vertical transverse semicircular canal, and its deepest portion reaches to a point below the floor of the tympanum.

Flesh[7] believes that the opening occasionally seen in the roof of the tympanic chamber is the result of maceration, and that the absence of bony covering in the living substance is an exceedingly rare occurrence.

The mastoid process contains but a single open space (antrum petrosum) in new-born children.[8]

Politzer enumerates the base of the styloid process among the component parts of the floor of the tympanic chamber.

The mastoid process, when examined in the dried bone of the adult, gives erroneous conceptions of the nature of the cells. Many of them are pneumatic, but others, according to E. Zuckerkandt,[9] are filled with fat. The proportion of air-cells and fat-cells is variable. In 39.8 per cent. of cases the cells are wholly pneumatic; in 20 per cent. wholly fat-containing; and in 43.2 per cent. both kinds were present in nearly equal proportions. The extension of the inflammation of the lining membrane to the mastoid cells is a complication which is thus seen to be dependent upon variations, and upon anatomical grounds alone is seen to be a lesion unlikely to occur in at least 20 per cent. of cases, from the fact that in this proportion no air-cells exist.

Berthold[1] concludes that the mucous membrane of the middle ear receives its trophic fibres from the fifth nerve. Evulsion of this nerve or its section was followed by "vascularization" and "purulent exudation." Similar treatment of the sympathetic and the ninth nerves had no effect.

The Ossicles.—The ossicles tell the story of their origin in the manner in which they vary, in the portions of the bones attacked by disease, and in the ratio of the attack itself among the several bones of the series. Both of the above statements again correlate with the facts of development, and in a measure with the condition of the bones in animals lower than man.

Additional Variations.—In addition to the variations already described on page 609, it may here be stated that as the stapes shows the widest range and greatest frequency of variation of any of the ossicles, so it is the most commonly affected by disease. It is also the bone which exhibits to the greatest extent the effects of advanced age. In this state the base of the stapes is subject to hyperostosis and as a consequence to impaired motility. Anchylosis between the stapes and the borders of the oval window may in like manner occur.

The fact that the stapes is an ossicle somewhat isolated in its development from the incus and the malleus, and that it has little or no genealogical significance, may account for its inconstancy in form, and its inability, relatively, as compared with the other ossicles, to resist the encroachments of diseased action.—While the stapes is the most variable the malleus is the least so. The short process and the handle may be absent in congenital defects of the tympanic membrane.

In a case of deaf-mutism reported by S. Moos,[2] the stapes was found in position, a part of the base being absent, while the incus and the malleus were absent.

The slender and short processes of the malleus may be united by a trace of a thin lamina which is homologous with the broader lamina constant in some carnivorous mammals. All the ossicles may

[1] Archiv f. Ohrenheilk., v.

[2] Trans. Path. Soc. Lond., 1859, x. 34.

[3] Knapp, Trans. Med. Soc. of New York, 1872.

[4] These remarks are to be considered as an addendum to the account of the middle ear, p. 604.

[5] Handbuch der mensch. Anat., 1820.

[6] Archives of Otology, 1879, viii. 53.

[7] Archiv für Ohrenheilkunde, xviii. 65.

[8] Wildermuth, Zeitsch. für Anat. u. Entwickelungsgesch. II.

[9] Monatsch. für Ohrenheilkunde, 1879. No. 1.

[1] Trans. Fifty-third Congress of German Scientists and Physicians, 1880.

[2] Arch. of Ophthal. and Otol. II., 1871, 39.

coalesce in a single rod which represents the columella of the lowest mammals, birds, and the cold-blooded terrestrial quadrupeds generally. The stapes and incus may be fused into a single bone. A supernumerary bone may lie between the malleus and the incus. The upper process of the incus may exceed the lower in size.

Diseased Action.—It has been seen above that the stapes exhibits a greater number of kinds of diseased action than either the malleus or the incus. Among additional facts may be mentioned that, while in the stapes the head and crura are most prone to caries, in the malleus it is the head of the bone which is most commonly attacked.

The handle of the malleus, owing to the fact that this portion of the bone receives its blood in part from an artery passing into the bone from the vessels of the tympanum, rarely becomes carious.

The incus, as it lies near the inner wall of the tympanum, is subject to exostosis. The space between the lower and upper processes may be filled with new formations of bone-tissue.

The ossicles may be entirely destroyed by caries independently of the rest of the ear.

The Articulations of the Ossicles.—The intrinsic or inter-serial articulations are as follows: the malleo-incudal, the incudo-stapedial, and the stapedo-vestibular. These are all of the nature of symphysis, according to Brunner.[1] The extrinsic articulations are confined to the malleo-tympanic and the incudo-tympanic junctures, and are less of the nature of articulations than of accessory union by ligamentous attachment.

The Muscles of the Middle Ear and of the Eustachian Tube.—The Tensor Tympani muscle has been found by Von Trœltsch to be continuous with the Tensor Palati either by a tendinous band or by a muscular fascicle. This connection explains the concurrence of retraction of the tympanic membrane with the action of the Tensor Palati as occurred in a case of C. H. Burnett.[2]—Paralysis and paresis of the muscles of the orifice of the Eustachian tube and of the Tensor Tympani have been found by Weber-Liel and E. Woakes to be associated. The former writer has found in paralysis of the Tensor Palati muscle antagonistic contraction of the Tensor Tympani to co-exist.

The concurrence of weakened and inefficient action of the two muscles may be anticipated, not only from the fact of partial fusion of the two muscles above mentioned, but from the fact that both receive nerve-fibres from the same source, namely, the otic ganglion. It would be a mistake to assume, however, that paresis of the tubal muscles of necessity is associated with paresis of the Tensor Tympani. The author has met with numerous examples of entire retention of the functions of the middle ear with paresis of the Tensor Palati and Levator Palati muscles.

The point of insertion of the Tensor Tympani has been found by V. Urbantschitsch subject to considerable variation. As the result of many dissections he found it twice only attached to the inner surface of the manubrium. In nineteen times it was attached to the outer, thirty times to both the outer and inner surfaces.

The Eustachian Tube.—The tube may be either narrower or wider than is normal. It may be unduly angulated at the osseous portion. The position of the pharyngeal orifice of the tube is subject to some slight variation. According to S. Moos,[1] the orifice becomes narrowed in chronic inflammation of the tube.

The Stapedius Muscle.—The pyramid and the Stapedius muscle can be occasionally seen in cases of perforation of the posterior quadrant of the tympanic membrane, and V. Urbantschitsch[2] has successfully divided the tendon of the muscle thus exposed for the relief of deafness and noises in the ear.

THE NOSE.

The Nose is the organ of olfaction. It is lodged in a chamber which is in the main of respiratory significance, and is defined by the bones of the face.

For convenience of description the nose is divided into—

The External Nose.
The Nasal Chambers.

THE EXTERNAL NOSE.

The External Nose (fig. 2, Plate XCIII.) holds the same relation to the nasal chambers as the auricle holds to the ear or the eyelids to the eye.

It is composed of—

The Nasal Bones.
The Nasal Cartilages.
The Nasal Muscles.
The Integument.

[1] Archives of Ophthal. and Otol. III., 1873, 145.
[2] Phil. Med. Times, 1875.

[1] Archives of Ophthal. and Otol., vi., 1877, 547.
[2] Wiener Med. Presse, 21, 1877.

The Nasal Bones are described on p. 138; and the Nasal Muscles on p. 249. The septal cartilage is not described.

The Nasal Cartilages are—

The Lateral Cartilages.
The Septal Cartilage.
The Sesamoid Cartilages.

The Lateral Cartilages are composed of the upper lateral and the lower lateral.

Each *upper lateral cartilage* is triangular in form, and is continuous with the cartilage of the septum. The anterior margin of each cartilage is thicker than the posterior, and is attached to the ascending process of the superior maxilla and to the nasal bone of the corresponding side of the face. The outer (lateral) border is visible within the vestibule, where it is covered with mucous membrane.

The *lower lateral cartilages* enter into the construction of the tip of the nose. They are distinct from the septum, and each cartilage is bent abruptly upon itself, the outer aspect of the angle being directed anteriorly. A depression often exists in the interval between the angles of the right and left lower lateral cartilages. One of the lines of bending—the internal—inclines toward the septal cartilage; while the other—the external—inclines toward the wing of the nose, and aids in defining the shape of the nostril. The inner line is much the smaller, and lies beneath the *septal cartilage* in contact with the similar process of the cartilage of the opposite side. It terminates abruptly at a point in advance of the anterior nasal spine of the superior maxilla. The outer line is broad and flat, and is subject to much variation in form.

THE SESAMOID CARTILAGES.

The sesamoid cartilages (accessory cartilages, epactal cartilages) are three or four in number. They are flat, subrounded nodules which are placed in the tough fibrous membrane of the wing of the nose. A conspicuous pair (vomerine cartilages) is placed one on either side of the nasal septum. In addition to the fibrous tissue and the sesamoid cartilages, the wings of the nose contain a quantity of fat and sebaceous glands. Hair follicles are also sparsely developed.

THE INTEGUMENT.

The integument is thin on the bridge and at the sides of the nose, where it is easily moved by the fingers. Toward the region of the cartilages the skin can be moved separately from the cartilages with difficulty, if at all. Two regions can be thus defined. The point at which the fingers are unable to raise a fold of skin from the external nose limits the region of the tip of the nose.

Remarks.—The cartilages constitute the main support of the lower part of the nose. Aquiline noses are apt to be associated with thin cartilages and with narrow nostrils; while small flat noses usually possess large rounded nostrils. The former variety is usually found in long narrow heads, and the latter in short high heads. The roof of the mouth is again usually more highly arched, and the alveolar ridges less curved in the former than in the latter. As a consequence of these facts, the external nose is of significance in correlation with the shape of the head and especially of the facial bones. In some individuals the extremes of these tendencies are so pronounced as to lead to the localization of diseased action in the nasal chambers. With the aquiline nose, nasal obstruction is often associated; and with the small flat nose, lack of proper protection of the nasal chambers.

THE NASAL CHAMBERS.

The Nasal Chambers (fig. 2, Plate XXIV.; fig. 152), as far as they are defined by the skeleton, have been described on pp. 152, 153. When the external nose remains in position, and the mucous membrane is intact, each nasal chamber may be divided into the nasal chamber proper and the vestibule.

The Nasal Chambers proper.
The Vestibule.

The Nasal Chambers proper are defined by the turbinated bones laterally, and the maxillæ and the palatal bones inferiorly.

The Vestibule is defined by the nasal bones anteriorly, and by the ascending processes of the superior maxillæ, and the nasal cartilages externally. Internally it is defined in part by the incisorial portion of the superior maxilla.

Each vestibule has the shape of a flask, flattened on one side, with the neck prolonged, compressed, and directed upward. The inner wall is formed below by the inner arm of the lower lateral cartilage, by a groove answering to the membranous septum, and above by the septal cartilage. The outer wall is formed by the outer arm of the lower lateral cartilage, by a depression behind it defined by the fibro-adipose tissue of the wing. The roof is continuous with that of the nasal chamber. The floor is depressed a little below the level of that of the nasal chamber, so that such an instrument as an Eustachian catheter is best introduced by first

elevating the tip of the nose. The superior orifice of the vestibule is a mere chink, and, in consequence, affords little or no aid in the introduction of instruments into the nasal chamber for the removal of morbid growths. The inferior orifice (the nostril) is an ellipse, whose internal border is nearly straight, and whose external border describes a curve with the posterior extremity, as a rule, more rounded than the anterior. Both outer and inner aspects of the vestibule near the nostril, as well as the pocket at the tip, are furnished with stiff hairs in patches. Looking at the nostril by the aid of a strong light, when the head is thrown back, one sees the following points: 1st, a darkish chink, far within which is the posterior orifice of the vestibule; 2d, on the outer side, the ridge formed by the inferior border of the upper lateral cartilage; 3d, on the same side, a ridge formed by the outer limb of the lower lateral cartilage.

At a point answering to the posterior border of the outer arm of the lower lateral cartilage, a voluntary contraction is made possible by the tilting of this border inward toward the septum, at the same time that the wing of the nose is depressed and abducted. Most persons can also occlude *one* nostril at a time by adducting the ala. This action, incomplete in man, is pronounced in many quadrupeds, in which we may presume occlusion of the vestibules may be announced by the powerful adduction of the cartilages of the wing directly to the septal cartilage.

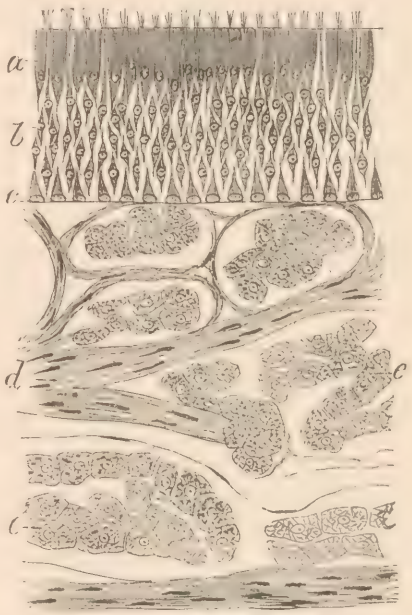
The nasal chambers are lined with mucous membrane which is thin, and resembles periosteum over the nasal bones, the ascending processes of the superior maxilla, the nasal cartilages, the floor of the nose, and the sinuses; but is erectile over the inferior turbinated bones, and the lower free border of the middle turbinated bones.

The nasal chambers may be considered as the repository of the *olfactory organs*, and as parts of the *respiratory apparatus*.

The Olfactory Organs. These are two in number; one for the left and one for the right nasal chamber. The left olfactory organ is composed of a special membrane which covers the median aspect of the left lateral mass of the ethmoid bone, and the upper half of the left side of the septum. The organ also includes the roof of the left nasal chamber. The right olfactory organ is composed of a similar membrane, which covers the median aspect of the right lateral mass of the ethmoid bone, the upper half of the right side of the septum, and the roof of the right nasal chamber.

The *olfactory membrane* is a modification of the mucous membrane of the interior of the nose. It is thick and soft as compared with the mucous membrane covering the nasal bones and the sinuses, but is not erectile. It is of a yellowish-brown color, and is rich in cellular elements, but in man at least not ciliated.

Fig. 151.



From a vertical section through the olfactory mucous membrane of the Guinea-pig. *a*, the epithelial cells; *b*, the sensory or olfactory cells; *c*, the deep epithelial cells; *d*, the bundles of olfactory nerve-fibres; *e*, the alveoli of Bowman's glands.

The accessory chambers to the nose include the frontal sinus and the maxillary sinuses. The nasal chamber also receives the lachrymo-nasal duct.

The Respiratory Apparatus. The respiratory portion of the nose may be roughly described as that portion which accommodates the air in its passage through the nose. The air in inspiration enters the nostril and passes into the pharynx at the posterior nares. In automatic breathing, the air passes scarcely at all in inspiration above the plane of the lower border of the middle turbinated bone, but an entrance into the region of olfaction, either between the anterior end of the middle turbinated bone and the nasal bone, or between the middle turbinated bone and the septum, may be held as possible. In expiration, the air entering each chamber at the posterior nares is carried along the floor of the nose, the middle meatus, and the space between the inferior turbinated bone and the septum. In many subjects the air also passes between the posterior end of the middle turbinated bone and the septum. The passage of the air in the nose differs in inspiration and expiration. In inspiration it possesses a

slight tendency to pass upward to the olfactory portion. When it is desired to have air pass freely into the olfactory portion, the act of sniffing is resorted to.

Variations.—The variations of the nasal chambers relate to the septum, to the turbinated bones, to the floor of the nose, and to the general subject of asymmetry.

The septum is frequently deflected in civilized races. The deflection occurs at the line of the ethmoido-vomerine suture, and is more pronounced anteriorly than posteriorly. The angulation in the septum may be so pronounced in the chamber as to permit the end of the deflected portion to be received in the opening of the maxillary sinus. The septum varies remarkably in thickness, especially in the lines of the ethmoido-vomerine suture, and at the surfaces of junction with the triangular cartilage. It is of uniform thickness at the posterior nares, where, however, the mucous membrane over it may be asymmetrically thickened.—The vomer at the base of the ethmoidal notch is subject to a peculiar form of hyperostosis, by which it is enormously thickened. With this condition are often associated an overgrowth and deflection of the superior maxilla where it enters into the composition of the nasal septum.—The vomer at the posterior nares may be deflected at its basal part. Connected with deflection of the nasal septum, and most probably dependent upon it, is a deviation of the cartilage of the septum.

Congenital perforation of the septum is occasionally met with. To determine the fact whether a given instance of septal defect be of congenital or of acquired origin, it may be well to remember that congenital defects are apt to be multiple, and the septal opening to be associated with the presence of a hyperostosis in the roof of the mouth, asymmetry of the facial bones, or other peculiarity, while acquired defect is apt to be of syphilitic origin, or to be the result of imperfect surgical operation. Congenital defects are, as a rule, in the triangular cartilage, just in advance of the ethmoidal notch, though they may be found in the perpendicular plate of the ethmoid bone.

The turbinated bones are subject to minute variation in form. The middle turbinated bone may be greatly reduced in size, and set relatively far back in the nasal chamber.

The floor of the vestibule may be raised above the plane of the nasal chamber proper, and conceal the lower border of the inferior turbinated bone (see fig. 152). The floor of the nasal chamber proper may present a shallow depression, and thus be exposed to inspection from in front of its entire length.

The chambers may be asymmetrical. The left is commonly the smaller. This contrast is particularly noticeable at the posterior nares, and is independent of the states of the nasal septum. The plane of the posterior nares, as a rule, slopes a little downward and forward.

Fig. 152.



An antero-posterior section of the face, exposing the lateral wall of the nasal chamber. The figure is designed to exhibit the difference in the plane of the premaxillary and the maxillary and palatal portions of the floor of the nose.

Remarks.—For clinical purposes, the nasal chambers may be studied under the following heads: (*a*) as divided into respiratory and olfactory portions; (*b*) as divided into the nasal chamber and the vestibule; (*c*) as divided into premaxillary, maxillary, and palatal portions; (*d*) as divided into the septum and the turbinated bones.

(*a*) *The nasal chambers as divided into respiratory and olfactory portions.* The air passing out from the pharynx, being confined to the plane of the posterior nares, is not carried up to the olfactory region, so that the odors on the expired breath are not appreciated.—When the communication between the respiratory and olfactory portions is cut off, as by swelling of the mucous membrane at the region of union of these portions, loss of smelling supervenes.—Discharge which may accumulate about the middle turbinated bone or in the upper portion of the vestibule cannot be removed by the act of blowing the nose, for the reason above assigned that the air of expiration cannot pass within the olfactory portion. The act of blowing the nose, or the process of washing out the nose by a current thrown in from the naso-pharynx, will wash out the inferior meatus with ease, provided the discharge be not inspissated, and the parts of the floor of the nose be not abnormally disposed.

(*b*) *The nasal chamber as divided into a nasal chamber and vestibule.* The distinction between the nasal chamber and the vestibule is, in the main, based upon the absence of erectile tissue in the vestibule, and upon the presence of a membrane (muco-periosteum) intermediate in character between skin and mucous membrane. Diseases of the vestibule are best treated as though they were affections of the skin; while diseases of the nasal chamber are to be treated on the same principles as those of the mucous membranes generally, especially of that variety of mucous membrane lying in contact with bone.

(*c*) *The nasal chamber as divided into the premaxillary, the maxillary, and palatal portions.* This method of dividing the nasal chamber is convenient for clinical topography of the nose. The positions of the sutural lines of the premaxilla (see p. 134), of the maxilla, and of the palatal bones determine the points at which the boundaries of the regions may be said to be fixed. These subdivisions of the nasal chamber are effected by the production of the planes of the sutures on the roof of the mouth, vertically upward through the nasal chambers.

(*d*) *The nasal chambers as divided into the septum and the turbinated bones.* The morphological significance of the septum, placed as it is in the median line of the face of the embryo, with the turbinated bones lodged to its right and left sides, remains the same in the skull of the adult, notwithstanding the fact that, with cultivated races at least, the septum is deflected the greater part of its course from the median line; with this deflection ensues acquired asymmetry of the nasal chambers. One of these chambers, commonly the left, is much smaller than its fellow of the opposite side, and may be occluded, when the right chamber will be larger than is normal and possess both osseous and erectile structures which have undergone physiological hypertrophy. Care should be taken to distinguish between such hypertrophy and the effects of diseased action.

GENERAL CONSIDERATIONS OF THE MUCOUS MEMBRANES OF THE BODY.[1]

The Mucous Membranes possess in common a cushiony, succulent, yielding surface, covered with a thick, glairy fluid termed mucus, which is secreted in great abundance by the mucous follicles, and with numerous special fluids, such as the salivary, gastric, biliary, and intestinal fluids.

Mucous membranes are in structure closely allied to the general integument. They are composed of an epithelial covering, which usually rests upon a delicate basement membrane; these two layers forming the covering of the matrix, which is composed of fibrous connective tissue with an admixture of elastic fibres. In contradistinction to the external integument or skin, it may be looked upon as the internal integument. The epithelial layer, owing to the constant moisture maintained upon it, never assumes the horny character of the corresponding layer of the skin, and is more or less translucent. Blood-vessels are often visible on a mucous surface, and, together with rich supplies of capillaries, give it its characteristic color.

The exact *color* of mucous membrane varies with the amount of blood held within it. Thus it is pinkish or reddish in the mouth and in the nose, and, owing to the presence of numbers of minute superficial veins, dusky in the pharynx and the œsophagus. When the glandular layer is well developed, the color is yellowish-pink, as upon the anterior surface of the soft palate, or of a light pink shade where the epithelium is thick, as upon the buccal surfaces. The anterior portion of the tongue, covered as it is with filiform papillæ, yields various colors which are consistent with health, and a still greater variety of tints in disease, in which it forms an index both of the retarded and increased epithelial desquamation in the digestive tract. The prevalent color is dull red with a shade of milkiness. When the mucous membrane is in contact with cartilage, as in the orifice of the Eustachian tube and on the vocal cords, the color is pearl-like. Within the stomach, as well as in the intestine, the color is of a grayer cast. The color of the rectum resembles that of the pharynx.

After death these tints disappear from the mucous membrane, and a dull slate or gray tint predominates. The color of the mucous membrane of the stomach undergoes the greatest degree of change, owing to the action of the gastric juice.

The mucous membrane is exceedingly loose and pliable at the side and beneath the tongue, and on the floor of the mouth as it passes from the tongue to the gum line of the lower jaw. It is also very lightly applied to adjacent parts between the base of the tongue and the epiglottis, and thence to the sides of the pharynx. In the œsophagus, the stomach, and the intestine, the mucous membrane is so loosely attached to the submucous coat, that it is capable of

[1] These remarks are applicable to all portions of the alimentary, the respiratory, and the genito-urinary tract, and their consideration will be conveniently undertaken at this place as an introduction to the anatomy of the splanchnic organs.

forming plications. These are, as a rule, most marked in such parts as are emptied of food and are here transient, but in some cases they are permanent. Among the last-named plications may be mentioned the valvulæ conniventes, and the spiral folds in the cystic duct of the liver. The folds of the rectum may also be classed in this category.

Exact knowledge of the relation existing between such or similar depositions of mucous membrane, and *local peculiarities* as expressed in *diseased action*, is meagre, but is susceptible of being formulated as follows: Wherever the mucous membrane is loosely applied to subjacent parts, inflammatory effusions occur therein with ease and rapidity. Hence the sudden swellings of the face which accompany inflammatory processes within or about the cheek (see also p. 251); the enormous size of the parts and their distortion in inflammation of the tongue; the danger of inflammation at the base of the tongue and aperture of the glottis by œdema and resultant narrowing of the aperture. On the other hand, intimate union of the mucous membrane to deeper parts prevents inflammatory swelling. If these conclusions be accepted, it is evident that the grade or duration of the morbid process cannot be estimated by the amount of effusion.—It is probable that where a serous membrane such as the peritoneum covers the mucous tract it acts as a preventive to submucous infiltration.

The mucous membrane is firmly attached to the alveolar processes of the upper and lower jaws, where, by its intimate union with the fibrous tissue about the bone, it forms the *gum-tissue*, or the *muco-periosteum*, by which term is meant a membrane combining the characteristics of mucous membrane and periosteum (see p. 621). The mucous membrane presents somewhat similar features where it lies in contact with cartilage, as in the nasal septum, the free portion of the cartilage of the Eustachian tube, and the larynx, and, indeed, along the entire respiratory tract below the structure last named. The term *muco-perichondrium* is appropriately used in relation to these structures. The parts covered by muco-periosteum are nourished through the membrane itself. As bone will perish when its periosteum is removed or inflamed, so bone denuded of muco-periosteum or covered with inflamed muco-periosteum will become necrosed. (See Remarks on the maxilla and the mandible, pp. 135 and 140, *infra;* also, on the inferior turbinated bone, p. 137.) The muco-perichondrium is less exactly associated with the nutrition of cartilage than is the muco-periosteum with that of bones, yet in one striking example, namely, in the muco-perichondrium covering the epiglottis and the arytenoid cartilages, it is recognized that prolonged inflammatory states will excite ulceration and death of the parts beneath. Wherever mucous membrane covers bone or cartilage, it is apt to possess a less degree of mobility than upon yielding structures such as the intestine. On the hard palate, the membrane is united by small fibrous trabeculæ to the ridges of the bony surface, the interspaces being occupied with racemose glands. At the roof of the pharynx, the membrane is fixed to the fibrous tissue of the base of the skull.

Upon the soft palate, it is more firmly adherent anteriorly, where it is in contact with gland-tissue, than posteriorly, where it lies over muscle-tissue. Upon the tongue, where it constitutes the cortex of that organ, it is also closely attached.

The mucous membrane of the alimentary canal belongs to the same variety as that of the respiratory apparatus, since the latter is seen, by its relation as well as its development, to be an offshoot from the former. Sharpey has given the name *gastro-pneumonic* to this variety to distinguish it from the *genito-urinary* mucous membrane.

The gastric portion of the tract becomes functionally distinct from the pneumonic portion at the lower portion of the pharynx. Above this region all the parts, namely, the mouth and nose, are related equally to the mechanism of digestion and respiration.

THE TONGUE.

The Tongue (fig. 1, Plate XCIII.) is a symmetrical muscular organ, lying on the floor of the mouth, and designed to aid in the prehension of food. It is accessory also to the sense of taste and the production of articulate sounds. The tongue, when at rest, is of an ovoidal figure (fig. 4, Plate XCIX.), whose base is abruptly truncated. When divided transversely, it is seen to be composed of a cortical and a medullary portion.

The *cortical portion* (cortex) is complete at the dorsum and at the sides, while absent beneath. It represents the mucous membrane of the floor of the mouth, which has become thickened upon the tongue for special purposes. The *medullary portion* constitutes the bulk of the organ, and is composed of interlacing bundles of the Palato-Glossus, the Stylo-Glossus, and the Genio-Glossus muscles.

The dorsum of the tongue, which embraces the

greater part of the cortical portion, is divided into two regions by the position of the V-shaped row of rounded eminences called the circumvallate papillæ. These are placed at the junction of the posterior third with the anterior two-thirds. The *posterior third* may receive the name of the *basal third* or *the base of the tongue;* while the *anterior two-thirds* may receive the name of the *apical portion.* By ordinary inspection the basal third is concealed in the living subject, where it aids in forming the anterior wall of the pharynx. It can be readily seen, however, by the aid of reflected light. The apical third is more movable, and is, to a certain extent, protrusile. It is that portion which is seen by direct light when the mouth is opened.

The *papillæ of the tongue* are of two kinds: the true papillæ and those belonging to the fibrous investment. The *true papillæ* are the more numerous, and are distributed everywhere throughout the surface of the organ. At the sides of the tongue, toward the palato-glossal folds, they are seen as rounded, or hemispherical tubercles, arranged in ridges, which are more or less vertical, and which gradually become interrupted and diminish in length as the tip of the organ is attained. The smaller of the papillæ have been named the *secondary* papillæ, and aid in giving prominence to the *primary* papillæ.

The *primary papillæ* (true papillæ) have been variously described, but may be considered as of three kinds: the circumvallate, the capitate, and the conical.

Fig. 153.



From a vertical section through the papilla foliata of a rabbit. Magnifying power about 90. *f*, folds in transverse section with stratified pavement epithelium; at the basis of each fold are seen the taste-cells; *g*, furrows between the folds; into them open *d*, the ducts of the serous glands; *l*, lymphatic vessel in the centre of the folds.

The *circumvallate papillæ* are the largest of the series, and are placed at the boundary between the oral and pharyngeal portions of the dorsum. As the name indicates, each is distinguished by being walled in by a prominent circle of secondary papillæ. The

Fig. 154.



From a vertical section through a circumvallate papilla of a child. Magnified about 50. *a*, fold of mucous membrane surrounding the papilla itself. *p*, the fungiform papilla, showing minute secondary papillæ. Of the stratified epithelium only the nuclei of the cells are shown. At the basis of the papilla are seen the taste-cells. *s*, serous gland; its duct opens at the base of the papilla; *m*, a small section of a lobule of a mucous gland between the lobules of the serous gland; *b*, the vascular mucosa; the holes are capillary vessels cut in different directions.

papillæ vary in number from ten to twenty, and are arranged in two lines which diverge obliquely. A median groove placed behind the circumvallate papillæ has received the name of the *foramen cæcum*. It may be absent or be double. A number of racemose glands may open in or about it.

The *capitate papillæ* are small and rounded, and are scattered over the tongue without special regularity, in a measure preserving the oblique direction behind, but slightly aggregated toward the tip. It is thought that within these the tactile sense of the organ chiefly resides.

The *conical papillæ* are the most numerous. They are arranged in lines which are parallel to the circumvallate papillæ in the neighborhood of these structures, but gradually become more transverse as the tip of the tongue is approached. They are covered with hair-like extensions of epithelial cells; hence the name often given them of *filiform* papillæ. The "*fur*" of the tongue is due to changes in these cells or to adherent foreign matters.

Bloodvessels.—The *arteries* of the tongue are derived from the lingual branch of the external carotid. They are remarkable for their large size, compared with that of the organ which they supply, and for the limited communication between the vessels of the two sides. Hyrtl demonstrates this anastomosis at but two points: one near the position of the circumvallate papillæ, and the other toward the tip of the tongue. An insignificant superficial artery lying along the line of the raphé would be the only vessel divided by a median incision upon the dorsum. The *veins* accompany the arteries and descend to join the internal jugular vein. The branches beneath the tongue are especially conspicuous when the tip is directed to the roof of the mouth.

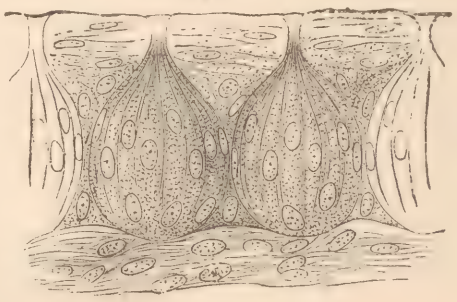
The extreme vascularity of the tongue has occasioned frightful loss of blood when the vessels have been opened in the course of the sloughing of cancer, as well as in non-malignant ulcerations extending into the tongue from the throat.[1] In the operation of dividing the frænum linguæ, the *ranine arteries*, by which name the abrupt terminal branches of the lingual artery are known, may be divided. Cruikshank is quoted[2] as having divided the frænum in a child which was discovered some time after the operation to be dead from loss of blood. An enormous coagulum was found in the stomach.

Owing to the distribution of the lingual arteries, each to its own side, unilateral glossitis may occur. Graves[1] has recorded a typical instance of the kind occurring in a medical student. The left half of the tongue was affected, and was so enlarged that the mouth could scarcely be closed; while the right side of the organ was in all respects normal.

After an injection of a solution of perchloride of iron into an epulis growing from the gum of the lower jaw, acute inflammation of the superficial veins of the tongue has been excited. The numerous instances of rapid serous infiltration of the supra-hyoid space can be accounted for only when the course of the lingual veins is considered.[2]

The nerves of the tongue.—The sensory nerves are derived from the lingual and glosso-pharyngeal nerves. The lingual nerve supplies approximately the anterior two-thirds of the organ and the glosso-pharyngeal the posterior third. Some of the terminations of each of the above-mentioned nerves are associated with remarkable organs known as taste-buds (taste-cells).—The motor nerve of the tongue is the hypoglossal.

Fig. 155.



Taste-cells of the tongue.

Variations.—The tongue is subject to many interesting variations. The entire organ may be too short, and the tip of the tongue cannot be brought readily against the roof of the mouth near the incisor teeth. The organ may be larger than is normal, and protrude from the mouth, causing great deformity in the position of the lower teeth. The condition known as "tongue-tie" is implied when the tip of the tongue is held to the floor of the mouth by a short and inextensive frænum. Tongue-tie interferes with the prehensile power of the tongue, and is enumerated among the causes of stammering. The dorsal curve of the tongue normally corresponds to the curve of the under surfaces of the hard palate and of the soft palate.—It is probable that minute congenital defects in the tongue, which interfere with the easy adaptation of the tongue to the palate, may also be among the causes of indistinct articulation and of stuttering. The tongue may be asymmetrical, not only from

[1] Amer. Journ. Med. Sci., series 1, 26, 193.
[2] Bell, Institutes of Surgery.

[1] Dublin Hosp. Rep., iv. 43.
[2] Holthouse, Trans. Clin. Soc. Lond., ii. 140.

congenital causes, but from those acquired as from paralysis. Romberg[1] has described a case of unilateral atrophy of the tongue.

Remarks.—The applications of a knowledge of the anatomy of the tongue to the study of disease are numerous and important. They will receive attention under the following heads: (*a*) the cortical portion; (*b*) the medullary portion; (*c*) localization of diseased action in the basal and apical portions; (*d*) fixation of the tongue; (*e*) distribution of the *fur*.

(*a*) The *cortical portion of the tongue* is the seat of a peculiar atrophic disease incident to syphilis, which has received the name of "bald tongue." It is recognized by the presence of smooth glossy patches which are remarkable for the absence of fur which may coat elsewhere the entire cortex. In a rarer disease —ichthyosis of the tongue—the cortical portion forms a white layer which has been compared to wet leather, or to a thin film of boiled albumen. It may be regarded as a form of epithelioma. Lingual cancer is believed by J. Hutchinson to be always of epithelial origin.—The circumvallate papillæ are often enlarged in strumous subjects.

(*b*) *The medullary portion.* The medullary portion, composing as it does by far the major portion of the organ, is remarkable for the ease with which it recovers from injury, and the size which it may attain in acute inflammatory conditions. In the treatment of wounds of the tongue it is well to remember that sutures are retained with difficulty. It is recommended to close the jaws firmly, so as to compel the injured organ to lie upon the floor of the mouth, and within the embrace of the sides of the inferior maxilla. In a wound of the medulla the adaptation is perfect when the tongue is thus placed.

(*c*) *The localization of diseased action in the basal and apical portions.* The circumvallate papillæ divide the tongue into two regions: one, comprising the anterior two-thirds of the dorsum, being supplied by the lingual branch of the inferior maxillary nerve; the other, the posterior third, by the glosso-pharyngeal nerve. The anterior region lies within the mouth, is almost without glands, and is covered by a derm-like involucrum closely held to the muscle; the posterior third lies within the pharynx (fig. 7, Plate XCIX.), is rich in glands, and is loosely covered by a thin, smooth mucous membrane.

Cancerous disease always begins in the anterior portion, and only passes behind the line of the circumvallate papillæ when the disease is wide-spread, the parts directly beneath its nidus being first involved. The disposition of the lymphatic vessels easily accounts for this fact. These vessels are numerous on the dorsum of the tongue, and are especially so, according to Sappey, until the line of the circumvallate papillæ is reached, when they abruptly cease, a few only passing to the pharyngeal portion. Nearly all of them unite to form on either side a main vessel of descent, which passes vertically through the muscular structure, and joins its special gland near the anterior belly of the Digastric muscle. Though the most common course of the disease is as above given, the pharyngeal region may be involved by cancer from in front. J. H. Moore[1] divided the lingual nerve for the relief of pain from cancer in the anterior part of the tongue; the relief was permanent as far as the lingual nerve was concerned, but when the disease invaded the area of the glosso-pharyngeal nerve, the pain recurred.

The presence of large numbers of glands in the pharyngeal portion of the tongue would suggest the frequent occurrence of glandular lesions here. They are, however, rare. In those few examples of cystic disease which have been recorded, no mention is made by the writers of the strictly local character which our knowledge of anatomy would lead us to expect this disease to assume. It is, however, likely that a cyst, forming at the base of the tongue, would find less resistance toward the fatty centre of the "medulla" of the tongue than toward the pharyngeal contour; a view which would harmonize with Salter's observation, that the branches of the follicles are often lodged in the parenchyma fully one-half or three-quarters of an inch from the orifice of the gland. The glands at the base of the tongue are capable of producing a free secretion of thick mucus. The following case[2] is given in exemplification of this fact, and also to show how long-continued pressure may be borne in a locality noted for its resistance to slight intrusions. A male, aged sixty, had for three months suffered from an abundant secretion of tenacious mucus in the pharynx, with hacking cough, and some dysphagia. After many attempts had been made by the patient to relieve the symptoms, the recorder extracted an upper set of artificial teeth from the pharynx, where they had rested directly upon the base of the tongue.—The glands are frequently hypertrophied in persons disposed to tuber-

[1] Klinische Ergebbnisse, Berlin, 1846; also J. H. Bennett, Clinical Lectures on the Principles and Practice of Medicine, fig. 122.

[1] Proc. Medico-Chir. Soc., 1862.

[2] J. Paget, Med. Times and Gaz., Jan. 18, 1862, 59.

cular disease, and are at times the chief cause of the irritative cough so noticeable in the first stage of phthisis.[1]

Fibrous tumors are of rare occurrence in this locality, but tend to be developed toward the base of the tongue. W. Hunt operated on a girl of sixteen, the basal portion of whose tongue was entirely occupied by a fibrous tumor. The patient died suddenly on the third day.

In acute glossitis the tongue may become enormously swollen, and life be threatened by pressure of the organ upon the larynx.

According to Erb, bilateral paralysis of the tongue is a characteristic feature of progressive bulbar paralysis. Incoördinated movements of the tongue are seen in chronic alcoholism, in other adynamic states as the typhoid condition, in some forms of chorea, etc. The prehensile portion, being supported to a less degree than is the basal, exhibits these changes almost exclusively.

(*d*) *Fixation of the tongue.* The tongue is the most movable of any part of the oral and of the hyoidean apparatus. The chief attachment of the organ is to the hyoid bone, but the Genio-Hyoid muscles are powerful tractors in maintaining the tongue in contact with the inferior maxilla. When these muscles are divided, as in the operation of amputation from beneath, the tongue falls backward and overlaps the glottis. The same position of the tongue is assumed in asphyxia and in some of the sequelæ of whooping-cough.

(*e*) *The distribution of the "fur."* The "*fur*" on the tongue is either confined to the basal third or to the anterior two-thirds of the dorsum. The basal third lies within the pharynx, and is covered with tenacious "*fur*" in many diseases of the pharynx and larynx, while the "*fur*" of the anterior two-thirds pertains more particularly to general states of the health. When the "*fur*" is confined to one side of the oral portion of the tongue, it may be due to local disease, as in an affection of the lingual branch of the fifth nerve, or to the irritation excited by a fragment of a tooth, etc.

[1] The tongue may be divided into an apical and a basal portion, which division answers pretty nearly to the division above adopted. These two portions in many animals are sharply separated by a difference in the plane of the upper free surface, the plane of the basal portion being higher than that of the apical. The apical portion is the *prehensile portion* in animals of the ruminant and edentate types, and in man is the portion which chiefly relates to the formation of many consonants.

The Alveolo-Lingual Groove.—When the tongue is at rest, there extends between it and the gum of the lower jaw a groove, which has received the name of the *alveolo-lingual groove*. Beneath the tip of the organ, this space is incompletely divided by the frænum. The base of the groove is distinguished by its whitish color, and has commonly upon its surface a vein whose thickest portion is directed from behind forward.

The Mylo-Hyoid muscle lies immediately beneath the surface, and, from its analogy to the Buccinator and Constrictor muscles of the pharynx, may be considered a submucous structure. The mucous membrane is but loosely attached to it. On either side the groove is marked by an irregular fimbriated line answering to the position of the sublingual salivary glands. Beneath the tongue on either side is seen the opening of the duct of the submaxillary salivary gland, which forms a little elevation sometimes called the *sublingual caruncle*. The alveolo-lingual groove is best developed in the negro.

Remarks.—The duct of the submaxillary gland (duct of Wharton) may be occluded by calculi, or, rarely, by foreign bodies. By the accumulation of saliva in the duct from these causes, a large *retention cyst* (ranula) may form. Mr. Jessop[1] mentions the case of a male, aged twenty-four, in whom the calculi had been noticed in the mouth for a year. Suddenly a swelling made its appearance, which so rapidly increased in size as to form by the fourth day a mass as large as a hen's egg. The patient suffered from pain in the neck, and had difficulty in breathing and swallowing. Two calculi, each the size of a pea, were removed from the right submaxillary gland, when a gush of retained saliva followed, and the symptoms subsided. The other conspicuous lesion of this region is cystic tumor. This disease has long been considered the result of obstruction of Wharton's duct; but, as shown by C. D. Weber,[2] is more frequently developed from the synovial sac, described by Fleishman as lying close to the frænum, on the outer side of the Genio-Glossus muscle, and beneath the mucous membrane of the tongue.—The pressure on the hyoid apparatus by a large cystic tumor is often sufficient to induce apnœa. Bransby Cooper narrates a case in which a prompt opening of the cyst was required to save the life of the patient.—Another form of cystic tumor, distinct from the foregoing, lies deeper than

[1] Br. Med. Journ., 1871, 120.

[2] Virchow's Archiv, vi. 27.

Fleishman's cyst, and, in developing, makes little or no impression within the alveolo-lingual groove; but, instead, expands within the supra-hyoid space.[1]—Erichsen[2] records a case in which he found collections of pultaceous caseous matter, probably sebaceous in character. Bryant[3] believes the sebaceous variety to be always congenital. Two cases came under his observation, both occurring in persons under twenty years of age.—The sublingual fold is often excessively enlarged as a complication of glossitis.—W. F. Clark[4] narrates a case in which the symmetrical enlargement of the sublingual folds, due to the irritation of a carious tooth, simulated cystic tumor. A horseshoe-shaped swelling was formed around the free portion of the tongue.

The Salivary Glands.

The Salivary Glands compose a system of racemose glands, six in number, which are arranged in pairs, and which open into the mouth.

The salivary glands are—

The Parotid.
The Submaxillary.
The Sublingual.

THE PAROTID GLAND.

The Parotid Gland (fig. 6, Plate XCIX.) is the largest of the salivary glands. It is lodged in the space between the lower jaw and the ear, which is hence known as the bed of the parotid gland. It extends a short distance downward below the lower jaw, forward over the posterior border of the Masseter muscle, backward over the Sterno-Cleido-Mastoid muscle, and inward as far as the styloid process. The gland is smaller and more fixed above, larger and more movable below. It is covered by the compact parotido-masseteric fascia, which prevents the form of the gland from being discernible through the skin.

The duct of the parotid gland, or the duct of Steno, is about two-and-a-half inches long, and a line in diameter; it extends forward, about eight lines below the zygomatic arch. It crosses the anterior border of the Masseter muscle, and terminates by penetrating the cheek opposite the first or second molar tooth.

The gland embraces the external carotid artery as it ascends to terminate in the temporal and internal maxillary arteries.

[1] Bell, Principles of Surgery.
[2] Ibid.
[3] Med. Times and Gaz., 1860.
[4] Davies's Surgery, 220.

The facial nerve crosses in its substance from before backward, and the auriculo-temporal branch of the fifth nerve ascends through it. Two lymphatic glands, each about the size of a pea, lie at the upper border, and one at the lower border. The weight of the gland is from five to eight drachms.

Variations.—A separate mass of the parotid gland, commonly of the size of an almond (socia parotidis), may be found lying at the anterior border of the Masseter muscle. The parotid duct infrequently divides at the anterior border of the gland into a slight upper and a stout inferior branch.

Bloodvessels and Nerves.—The bloodvessels of the parotid gland are derived from the external carotid and the facial arteries. The gland receives nerves from the auriculo-temporal branch of the fifth nerve and from the anterior branch of the first cervical ganglion of the sympathetic system.

Remarks.—In health the parotid gland cannot be said to have a well-defined capsule. But in diseased conditions a capsule is formed which enables the operator to enucleate the gland with comparative ease—the situation of the gland, and the important vessels traversing it, however, at all times making this a serious undertaking.

It is important for several reasons to remember the bearings of the parotido-masseteric fascia. A swelling forming beneath it, as in mumps, is prevented from appearing on the surface, and is seen to best advantage upon the neck below the angle of the jaw,[1] or, more rarely, within the pharynx, where it interferes with deglutition and the depression and elevation of the lower jaw. Pus, forming beneath the fascia, gives little or no evidence of its presence. If a swelling due to this cause be present, it is of a flattened form.[2] Sometimes the fluid, not finding vent externally, passes posteriorly, and finds exit into the external auditory meatus.[3]

When a tumor is removed from over the parotid gland, it follows that the parotido-masseteric fascia is destroyed: and should the growth recur, it will from this fact be more conspicuous upon the face, since its development no longer is resisted by the fascia.[4]

The free inferior lobe of the parotid may be the seat of separate diseased action. Growths from this portion of the gland may affect the pharynx indirectly by pressure, or directly by transmitted diseased action.

[1] According to Monteggia (Malgaigne, Chir. Anat. 1, 455), the swelling of the parotid gland in inflammation may press the condyloid process forward, thus simulating dislocation of the lower jaw.
[2] Hyrtl, Topog. Anat., 1, 331.
[3] Velpeau, Chir. Anat., 1, 26.
[4] Hyrtl, Topog., loc. cit. 338.

It has been shown by Allan Burns that a sacculated condition of the lobe, originating behind the lower jaw, may spread downward and laterally upon the neck.[1]

Aneurismal conditions of the vessels of the gland may produce symptoms of suffocation, and give rise to pulsating tumors in the region of the tonsil.

The superficial portion is rarely the seat of cancer. The disease almost invariably begins in the deep portion of the gland, and early involves the facial nerve by pressure.

Cystic tumors, on the other hand, may be found within the superficial portion only. Fergusson has formulated a good rule on the subject of parotid tumor: If the skin can be freely lifted from over the tumor, it is probable that the tumor may be removed, whether cystic or otherwise, without necessitating the removal of the entire gland; but the skin, if tense, infiltrated, and fixed, indicates that the entire gland is involved.

Tumors may arise within that portion of the gland overlying the Masseter muscle; these may be due to engorgement of the *socia parotidis* or be the result of occlusion of one of the accessory ducts. They are at first freely movable, painless, and excite at times an increased flow of saliva. It is important to discriminate between these swellings, enlargements of the lymphatic glands of this region, and incipient enchondromata. The tumors last named are elastic, and resemble small cysts, for which they have often been mistaken.

Inflammatory obstruction of the parotid duct will cause intumescence of the gland, yielding unusual symptoms. Since the duct of Steno cannot be traced deep within the body of the gland, the swelling will be confined to the superficial portion. The mass differs from other swellings of the region by the presence of a ridge, seen also within the mouth, placed between the Masseter muscle and the cheek. There is sometimes little or no pain, at others a sense of soreness only. This rare condition was first accurately described by Allan Burns (loc. cit.).

A fatal case of abscess of the parotid gland involving the temporo-facial vein has been recorded by Murchison.[2]

THE SUBMAXILLARY GLAND.

The Submaxillary Salivary Gland (fig. 6, Plate XCIX.) is about a third smaller than the parotid, and of a subrounded shape. It lies entirely within the neck, between the Digastric muscle below and the lower jaw above. In part it is received within a depression on the lower jaw, beneath the oblique line, and in part rests upon the Mylo-Hyoid muscle. The lobules of the gland are somewhat more pronounced than those of the parotid, and are less compactly arranged. The gland tissue accompanies the duct (here called the duct of Wharton) as it passes backward to the border of the Mylo-Hyoid muscle, and winds round it. The duct as it lies upon the upper surface of the muscle has the sublingual gland above it, and terminates in the mouth near its fellow by a prominent projection at the side of the lingual frænum.

Bloodvessels and Nerves.—The submaxillary gland is supplied by branches of the facial and lingual arteries, and by nerves from the submaxillary ganglion.

Variations.—The gland may partially surround the lateral border of the Mylo-Hyoid muscle. Separate lobules may be attached severally to the duct of Wharton beyond the limit of the main gland.

For remarks see Alveo-Lingual Groove.

THE SUBLINGUAL GLAND.

The Sublingual Gland is a convenient name for a group of glands lying beneath the mucous membrane of the floor of the mouth, and constituting the ridge which extends from the outer side of the sublingual caruncle, about an inch and a half, to the first molar tooth. The separate glands are from six to eight in number, and their several ducts are known as the ducts of Rivinus. Two or three of the smaller glands may unite to form a single duct. The most noteworthy of these ducts is one running toward the sublingual caruncle, and sometimes tributary to the duct of Wharton, called the duct of Bartholin. The glands lie above the Mylo-Hyoid muscle, and the duct of Wharton rests upon the Genio-Glossus muscle.

Bloodvessels and Nerves.—The arterial supply of the gland is derived from the submental and sublingual arteries. The nerves are derived from the submaxillary ganglion.

THE TEETH.

The Teeth (figs. 1, 2, 3, 5, Plate XCIX.) are special structures developed from the mucous membrane of the mouth, but lodged in the jaws, and designed to cut, to tear, and to grind the food. They are of four kinds—named in order from the front to the back of the jaws—the incisors, the canines, the bicuspids, and the molars; and of two sets, the permanent,

[1] Surg. Anatomy of the Neck, Edinburgh, 1823, 303.

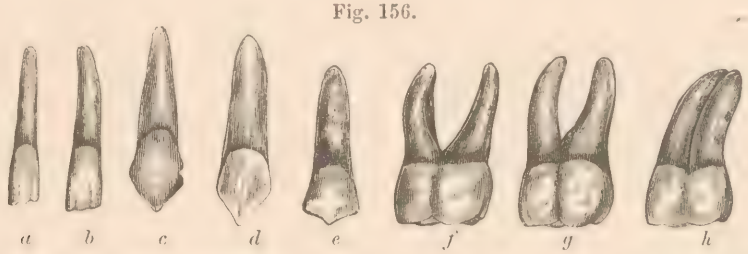
[2] Trans. Path. Soc. London, 1859, x. 99.

and the deciduous (milk teeth, temporary teeth). The permanent teeth are thirty-two in number, four incisors (two central and two lateral), two canines, four bicuspids, and six molars in each jaw The deciduous teeth are twenty in number, four incisors, two canines, and four molars in each jaw.

The teeth are so arranged in pairs that on each side of the upper and of the lower jaw one or more examples are found of the incisor, canine, bicuspid, and molar types.

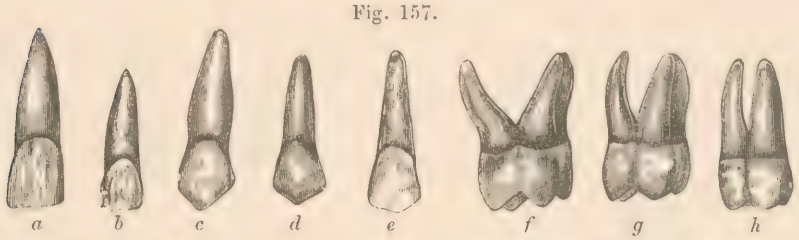
The teeth of the permanent set will be first described.

Fig. 156.



Lower permanent teeth of the right side. *a*, central incisor; *b*, lateral incisor; *c*, canine tooth; *d*, first bicuspid; *e*, second bicuspid; *f*, first molar; *g*, second molar; *h*, third molar.

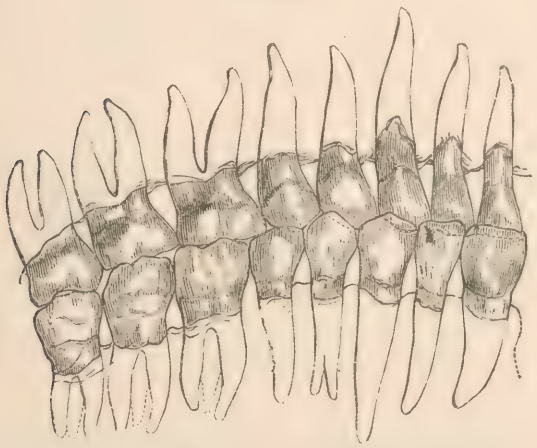
Fig. 157.



Permanent teeth of the left side of the upper jaw. *a*, central incisor; *b*, lateral incisor; *c*, canine tooth; *d*, first bicuspid; *e*, second bicuspid; *f*, first molar; *g*, second molar; *h*, third molar.

General Characters of the Teeth.—Each tooth presents for examination a crown or body, a root or fang, and a neck. The crown is the erupted portion, and is covered with enamel. The root is imbedded in the

Fig. 158.



The teeth of the permanent set of a single side in apposition.

alveoli of the jaws, and is covered by periosteum (odonto-periosteum, periodontium). The neck is the slightly constricted portion of the tooth which lies between the crown and the root. It is ordinarily concealed from view, but may become exposed in persons past middle life.

THE INCISORS.

The Incisors (figs. 159–161), or cutting teeth, are eight in number—four in each jaw. They closely

Fig. 159.

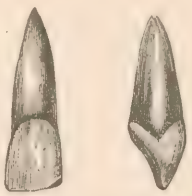


Fig. 160.



Fig 159.—Upper central incisor, front and side views.
Fig 160.—Central incisor lower jaw, front and back views.

resemble one another, and may be described together. They present chisel-shaped crowns, which widen

Fig. 161.



Fig. 162.

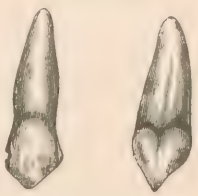


Fig. 161.—Lateral incisor lower jaw, front and side views.
Fig. 162.—Canine of the upper jaw, front and side views.

toward the cutting edge, and elongated roots, which are compressed from side to side. The median border

of the crown is nearly straight, the lateral (outer) border is slightly convex, and, in the upper jaw, directed obliquely downward and outward, the peculiarity last named being best seen in the superior lateral incisor. The cutting edge of the newly erupted crown is ordinarily marked by three minute serrated inequalities, which are soon lost, and the anterior surface by from one to three faint longitudinal grooves. The general contour of the edge of the fully developed tooth is slightly curved (laterally) downward; a peculiarity best seen in the lateral tooth. The posterior surface ordinarily exhibits a triangular concavity occupying about two-thirds of the entire surface. Between the apex of this space and the neck of the tooth there is a rounded prominence, and at the sides are well-defined ridge-like borders which are continuous with the median and lateral contour-lines.

THE CANINE TEETH.

Fig. 163.



Canine tooth of the lower jaw, front and side views.

The Canine teeth (figs. 162, 163) are four in number—two in each jaw. They are the largest teeth in the series. The crown projects slightly below the other teeth in the upper jaw, and above them in the lower. The root, which is twice as long as the crown, is deeply imbedded in the structure of the superior maxilla. The general form of the crown is conical, with a triangular depression posteriorly, which is smaller than the similar space on the incisor. The lateral walls also are thicker than in the incisor, and the basal prominence is larger. The root is grooved upon its lateral surface. The cutting edge is composed of two oblique converging surfaces of which the median is the smaller.

The term "eye-tooth" is often given to the superior canine. Its application is supposed to be due to the fact that inflammation of the root may lead to inflammation of the appendages of the eye.

The lower canine tooth is sometimes called the "stomach tooth."

THE BICUSPID TEETH.

The Bicuspids (premolars) (figs. 164–167) are eight in number, four in each jaw. As the name implies, they present two cusps or prominences, separated by a deep transverse fissure on the grinding surface of the crown. The outer (buccal) cusp, the larger of

Fig. 164. Fig. 165.

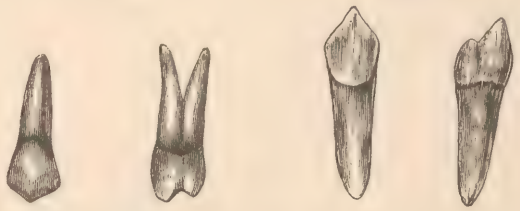


Fig. 164.—First bicuspid of the upper jaw, front and side views.
Fig. 165.—First bicuspid of the lower jaw, front and side views.

the two, is more or less tri-hedral; the inner (palatal) cusp is conical. The two are united at the median

Fig. 166. Fig. 167.



Fig. 166.—Upper first bicuspid, front and side views.
Fig. 167.—Second bicuspid of the lower jaw, front and side views.

and lateral borders by a ridge, the median border being the more robust. The root is compressed laterally, and is grooved on either side.

THE MOLARS.

The Molars (grinders) (figs. 168–170) are twelve in number, six in each jaw. They are of quadrilateral form and diminish gradually from the first to the third. Each crown presents four cusps, of which the antero-

Fig. 168. Fig. 169. Fig. 170.



Fig. 168.—First molar of the upper jaw.
Fig. 169.—Third molar of the upper jaw.
Fig. 170.—Second molar of the upper jaw.

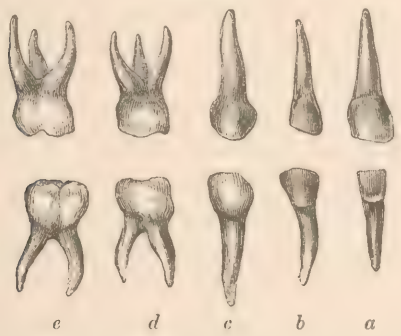
internal (medio-palatal) is the largest, and the postero-internal (latero-buccal) commonly the smallest. In the superior molars the antero-external (medio-palatal) and the postero-external (latero-buccal) apparently blend, forming an oblique ridge on the grinding surface of the crown separating the remaining cusps. The median border of the grinding surface is limited by a ridge uniting the two anterior (median)

cusps. The buccal and lateral sides of the crown are marked by faint fissures which are continuous with the sulci on the grinding surface, while the median and palatal sides are unbroken. The roots are three in number, of which the inner or palatal is the largest and most divergent, the two outer or buccal roots being as a rule parallel with each other and united at the crown.

The last molar or wisdom tooth is the smallest of the three, and exceedingly irregular in form.

As a rule the two anterior (median) cusps and the median ridge are constant, but the two remaining cusps are apt to be small and the postero-external (latero-buccal) may be absent. In all the molars this last cusp is the smallest, and may not reach to the level of the others. The roots of the wisdom tooth may be entirely confluent and somewhat deflected from the axis of the crown. In the inferior molars the cusps are of nearly equal size, and separated by a deep cranial sulcus. The crowns are more oblong from the median to the lateral border than is the case with the superior molars. The crowns are two in number and compressed medio-laterally.

Fig. 171.



The deciduous teeth of the right side in the upper and the lower jaws. *a*, central incisors; *b*, lateral incisors; *c*, canine and stomach teeth; *d*, first molars; *e*, second molars.

THE DECIDUOUS TEETH.

The Deciduous Teeth (figs. 3, 5, Plate XCIX. figs. 171–173) (milk teeth, temporary teeth) are twenty in number. They resemble in their general features those of the permanent set, though at the junction of the neck and crown the enamel is apt to have a slightly bulging appearance, which is best seen in the molars. The canines are relatively shorter, while their crowns are broader than their successors. In the molars the ridges are often developed at the expense of the cusps. In the bicuspid tooth the ridge uniting the cusps on their median border frequently assumes the form of a trenchant fold of enamel.

Fig. 172. Fig. 173.

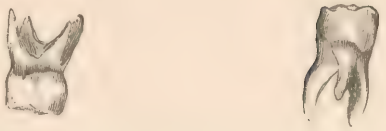


Fig. 172.—Upper second deciduous tooth with four roots.
Fig. 173.—Lower second deciduous molar with three roots.

Variations.—The teeth are very variable in form, so that it is difficult to frame any description which will not be open to exception. A few general principles may be of use in enabling the student to identify readily any departure from the above outline description.

(1) For every cusp there is a tendency to form a distinct root.

(2) All cusps tend in variation to assume the conical form. A tooth with a single cusp, as the incisor, may be said to be a cone compressed from before backward; and a canine tooth, a cone slightly excavated posteriorly.

(3) The inflections between the conical crown and its basal eminence described in connection with the incisors and canine teeth are sufficient to define every possible modification of form in the crowns of these teeth.

(4) This basal eminence in the human tooth is of the same value as the *cingulum* of the teeth of some quadrupeds.

(5) The incisor and canine teeth are composed respectively of a single modified cusp and an insignificant basal ridge or *cingulum*.—A bicuspid tooth is composed of a primary cusp, and a larger cingulum, which, however, never attains the size of the primary cusp. In the bicuspid tooth the cingulum enters upon the grinding surface, where it is functionally active, and where it may receive the name of a second cusp.—The molar tooth retains the two cusps of the bicuspid tooth, and in addition secures a third placed upon the outer or buccal side of the others. Upon the palatal side (opposite the latter), is a large cingulum, which is almost coequal with the true cusps, but enters less completely upon the grinding surface. These features distinguish the first and second superior molars. The third superior molar or wisdom tooth resembles closely a bicuspid in the general absence of the cingulum and in the retention of the molar cusp in a comparatively active condition. The lateral surface of the crown of a wisdom tooth is apt to present no sulci, thus resembling a similar surface of the bicuspid tooth.

(6) In the lower jaw all four of the conical points of the grinding surface are engaged in the trituration of food. If any additional conical eminences be present, they almost invariably appear upon the buccal surface.

(7) The union of the inner and outer cusps of a bicuspid tooth by a ridge, and the subsequent appearance of this ridge in uniting the anterior pair of cusps are not characteristic of the human teeth, but are best seen in the teeth of the East Indian monkey (*Semnopithecus*) and in those of the baboon (*Cynocephalus*). Occasionally in supernumerary incisor teeth

the cingulum may assume the characters of a cusp, in which event the incisor can be distinguished with difficulty from a bicuspid tooth as far as the crown is concerned.

The roots of the upper molars may be four in number. The roots of the upper molars tend in variation to diverge, while those of the lower molars tend to converge.

Eruption of the Teeth.—The deciduous incisors, as a rule, are erupted before the large fontanel closes. Thus the first incisor appears at the age of six or seven months, and the large fontanel is closed at twelve. The fontanel is entirely ossified at the third year.

Development.[1]—The teeth are developed from the oral mucous membrane in the following manner: In the seventh week (fortieth to forty-fifth day) a faint groove appears upon the surfaces of the jaw in the position of the future dental arch. Owing to the increased growth of the epithelial cells along the sides of the groove the membrane appears slightly swollen. Coincident with this a fold of the deeper layer of the epithelium carrying with it the layer of cylindrical cells (the Malpighian layer) descends with the groove and occupies its entire length. It is, in a word, a distinctly specialized structure growing from the oral epithelium in the same manner as glandular organs arise. Thus lodged, it expands at its free or lower portion, and becomes thinned at its upper attached portion. The former becomes concave beneath to adapt itself to a conical projection that is seen growing upward from the embryonic tissue of the jaw. The epithelial growth is now divided transversely into a number of separate processes, each of which is attached to the side or top of the groove by a distinct stem. At this time each involuted portion might be compared to a bell-glass with a long handle or to an inverted letter ⅄ (Tomes).

The groove is now closed above by the oral mucous membranes, and no trace remains of the peculiar process of involution by which a fold of epithelium has been imprisoned beneath. The groove thus becoming obliterated and each papilla being in relation to its own enamel organ, the remainder of the enamel-riband disappears, and membranous partitions separate the sacs of the developing teeth from one another. These partitions by their ossification form the future alveoli.

This process of epithelium is the germ of the enamel, and is hence called the *enamel-organ.* The papilla to which it is adapted contains the germ of the dentine, and is called the *dentine-organ.*

The enamel-organ adapts itself accurately to the growing dental papilla, defines the crown of the future tooth by terminating at the neck, and firmly embraces the papilla by a well-defined constriction. It is thickest over the apex of the dentine-organ, but becomes thinner as it approaches the base.

The closure of the follicle is coincident with the absorption of the stem of the enamel-organ, which for the remainder of the development is nourished by the wall of the follicle.

The upward growth of the dental papilla and its hood causes absorption of the stem of the latter, and from the time of its disappearance the enamel-cup is called the enamel proper of the tooth, and no trace of its peculiar origin is seen. The dentinal structures form successively from without inward in the papilla, thus narrowing the use of the soft structures, and serving to limit the future pulp-chamber. The roots of the teeth grow as the papilla ascends, and receive their cemental coverings by changes in the wall of the sac, which are almost identical with the process of the development of bone from membranous structures.

Development of the permanent teeth.—At the sixteenth week a second diverticulum similar in kind to the first passes downward to the inner side of the deciduous tooth-sac. The sixth-year-molar is *primary, i. e.,* is a bud-like growth; it arises from the epithelium from the same layer which yields the first enamel-organ germ. At the third month the twelve-year-molar bud arises from the neck of the enamel-organ, thus constituting a *secondary* outgrowth, while at the third year the bud-like growth which evolves the eighteen-year-molar, thus in its turn constituting a *tertiary* outgrowth, takes its origin.

Structure of the enamel-organ.—The enamel-organ consists of three layers: first, the internal epithelium, which forms the enamel proper of the perfected tooth; second, an internal epithelium, which is composed of simple rounded cells and is absorbed during the process of eruption; and a third or intermediate layer (called the *stratum intermedium*) which serves the purpose of nutritive substratum to the other two (Tomes). It is composed of cells having distinct nuclei and ramified processes, which latter freely anastomose. The enamel-organ is smooth where it covers the dentine-organ, but is indented by numerous papillary projections on its outer surface.[1]

The dentine arises from calcification in the interstices of the cells — forming the intertubular substance. This is not a negative process, but the result of certain changes in the cells by which a special

[1] See also p. 60.

[1] LeGros and Magitot, Journ. of Anat. et Phys. 1881.

substance is thrown out and excites the intercellular matrix to appropriate lime-salts from the blood. The cells themselves form the elongated and branched tubules.

The cementum differs from the enamel and dentine in deriving the material for hardening directly from periosteal vessels. According to LeGros and Magitot, the external portion is thin, rather dense and opaque, and retains a fibrous, laminar, felt-like arrangement of its fibres. The internal portion is thick, soft, and transparent, and is made up of nascent connective tissue. Over the surface of the enamel-organ the wall is vascular, and forms a number of villoid processes which project into the external epithelium. (Waldeyer.)

The following table has been drawn up from the data furnished by LeGros and Magitot: At the seventh week of development are formed the beginnings of the enamel-organs. At the ninth week traces of the dentine-organ. At the fifteenth week the epithelial bud begins to be transformed into the enamel-organ. At the sixteenth week the follicle is closed, and the mucous membrane is independent of it.

Remarks.—The teeth may be changed in position by steady pressure. Tumors will thus displace teeth. Enlarged states of the tongue will turn the crowns of the teeth in the direction of the lines of pressure. A similar malposition results from a premature union of the two halves of the lower jaw, the tongue being of normal size. The teeth may be distorted by pressure of a nævus or other tumor.[1] Lack of proper development of the superior maxillæ contracts the dental arch, and the teeth assume irregular positions. The act of thumb-sucking in a child will spread the superior dental arch and distort the roof of the mouth.

Teeth are often the seat of hyperostosis of the roots. In the lower jaw suppuration about the roots of a tooth may involve the connective tissue of the suprahyoid space. As the result of acute periodontitis and subsequent inflammation of the cancellous structure of the inferior maxilla, suppurative cellulitis of the structure of the floor of the mouth and of the tongue may ensue and has infrequently proved fatal.

THE PHARYNX.

The Pharynx (fig. 7, Plate XCIX.) is that muscular pouch which is controlled by the Constrictor muscles. It extends from the base of the skull to the cricoid cartilage, and serves to unite the mouth and nasal cavities with the œsophagus and the larynx.

[1] Bryant, Treatise on Surgery, 198.

As observed in the dissected subject, the pharynx is defined posteriorly and laterally by the Constrictor muscles (figs. 1, 2, Plate XLV., p. 260), superiorly by the fibrous tissue at the base of the skull. Inferiorly the pharynx is narrowed, and, as already mentioned, is continuous with the œsophagus and the larynx. The anterior border of the pharynx corresponds to an imaginary plane which unites the two pterygo-maxillary ligaments, *i. e.*, at the anterior limits of the Superior Constrictor muscle.

The pharynx is five and a half inches long, two inches wide at its widest part, and about an inch wide at its narrowest part. The mucous membrane is in health soft, smooth, flexible, and of a darkish red color.

The pharyngeal fascia.—The pharyngeal fascia (pharyngeal aponeurosis) is a fibrous membrane which extends downward from the base of the skull in the substance of the posterior wall of the pharynx. It is at first thick, but soon becomes thin, and is finally lost at about the line of the junction of the middle with the upper third of the pharynx. A second fascial extension, which serves to strengthen the lower portion of the pharynx, extends from the hyoid bone toward the tongue.

Zaufal[1] describes a division of this fascia (plica salpingo pharyngea) which extends from the cartilage of the Eustachian tube to the fascia in the posterior wall of the pharynx. It is held by S. Moos to be a result of diseased action.

The region between the pharynx and the vertebral column is occupied with a quantity of loose, glairy connective tissue which enables the movements of the pharynx to take place (notably the constriction of its muscles) without friction.

The pharynx is divided into three portions—

The Naso-pharynx,
The Oro-pharynx,
The Laryngo-pharynx.

The Naso-pharynx (retro-nasal portion of the pharynx) is a space which answers to the posterior prolongation of the nasal chamber. That is to say, the lateral wall of the naso-pharynx is about in the plane of the corresponding wall of the nasal chamber; so that the plane of the upper surface of the soft palate answers pretty nearly to that of the floor of the nose. It extends from the basilar process of the occipital bone to the soft palate and to an imaginary line drawn thence backward to the vertebral column.

[1] Archiv f. Ohrenheilk., xv. 1879, 96.

Defining the anterior wall of the naso-pharynx are the posterior nares and the posterior free edge of the vomerine septum. At the sides are the openings of the Eustachian tubes. On either side, extending obliquely from the lower borders of the tubes to the soft palate, is a fold of membrane covering the Levator Palati muscle known as the *salpingo-palatal fold.* Between the orifice of the Eustachian tube on each side and the posterior wall of the naso-pharynx is a depression, chiefly defined by the inward (pharyngeal) projection of the cartilage of the Eustachian tube, known as the *fossa of Rosenmüller.* Hanging from the roof of the chamber is the so-called *pharyngeal tonsil,* which is a sessile collection of lymphoid bodies. The naso-pharynx is about one-and-a-half to two inches in height and from eight lines to one inch in width.

The Oro-pharynx (fig. 7, Plate XCIX.) is less constant in form than the preceding. The chamber narrows below where it is continuous with the laryngo-pharynx. The oro-pharynx extends from the inferior border of the soft palate (and its produced plane) to the level of the cornu of the hyoid bone and to the parts extending thence backward on that plane. Upon the lateral wall lies the tonsil, and behind the tonsil, extending from the soft palate to the lower part of the pharynx, is a conspicuous fold over the Palato-Pharyngeus muscle, named from its situation the *palato-pharyngeal fold* (posterior half arch). In front of the tonsil is a second fold, much smaller than the foregoing, which is the *palato-glossal fold* (anterior half arch), and which answers to the position of the Palato-Glossus muscle. The space between these folds on the side of the pharynx, and occupied by the tonsil, is called the *tonsillar space;* that between the two tonsils, the *inter-tonsillar space.*[1] The space between the palato-glossal folds is the *oro-pharyngeal aperture;* that between the palato-pharyngeal folds, the *naso-pharyngeal aperture.* The posterior free edge of the soft palate forms at once the upper margin of both the preceding apertures.

The Laryngo-Pharynx extends from the level of the greater cornu of the hyoid bone to the lower border of the cricoid cartilage. It is defined in front by the basal third of the tongue.

Bloodvessels.—The arterial supply of the pharynx is derived from the ascending pharyngeal branch of the external carotid and the ascending palatine branch of the facial artery; it includes also small twigs from the internal maxillary.

The veins form a plexus which empties into the internal jugular vein, though some are bubulary to the occipital veins. Luschka recommends cupping the nape of the neck to relieve pharyngeal congestions. The same writer[1] speaks of frequently finding varicose conditions (with contained concretions) of these veins. Often some of the veins of the soft palate and the interior of the pharynx are visible on inspection of the parts in the living subject.

Nerves.—The nerves are derived from the pharyngeal plexus and branches of the pneumogastric nerves, and the spheno-palatine ganglion. The sensibility of the naso-pharynx is much lower than is that of the oro-pharynx or that of the laryngo-pharynx. A foreign body may be retained in the naso-pharynx without exact sensations as to its locality. The sensibility of the laryngo-pharynx is more highly developed than that of any other portion of the pharynx.

The inferior portion of the pharynx receives branches from the laryngeal nerves. The pharyngeal branch of the superior laryngeal nerve forms upon the surface of junction of the larynx and pharynx (recessus pharyngo-laryngeus, Luschka) a fold of mucous membrane which has been named by Hyrtl[2] the *plica nervi laryngei.*

[1] The author proposed these terms in a memoir entitled "The Soft Palate in Health and Disease," Trans. Am. Med. Assoc., 1872, 537.

[1] Schlundkopf, Tübingen, 1868, 113.

[2] Lehrbuch der Anatomie, 657.

EXPLANATION OF PLATE XCIX.

Fig. 1. The permanent teeth of the upper jaw in position, seen from beneath.

Fig. 2. The permanent teeth of one-side of both the upper and the lower jaw.

Fig. 3. The deciduous teeth of the upper jaw, seen from below.

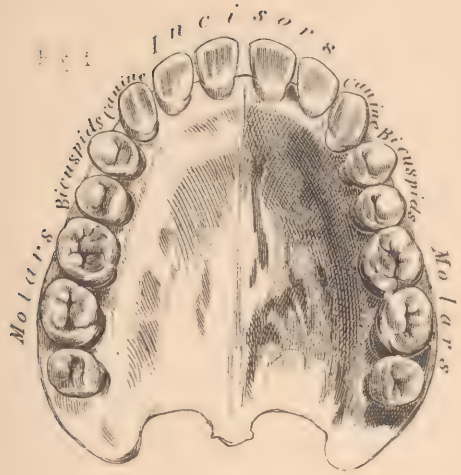
Fig. 4. The oral aspect of the soft palate and related parts.

Fig. 5. The deciduous teeth of the lower jaw.

Fig. 6. The Parotid and submaxillary salivary glands in position.

Fig. 7. The pharynx, represented as opened from behind in order to display the naso-pharynx, the base of the tongue, and the larynx. A portion of a glass-cylinder, which has been placed in the œsophagus to distend it, is seen at the lower part of the figure.

Fig 1



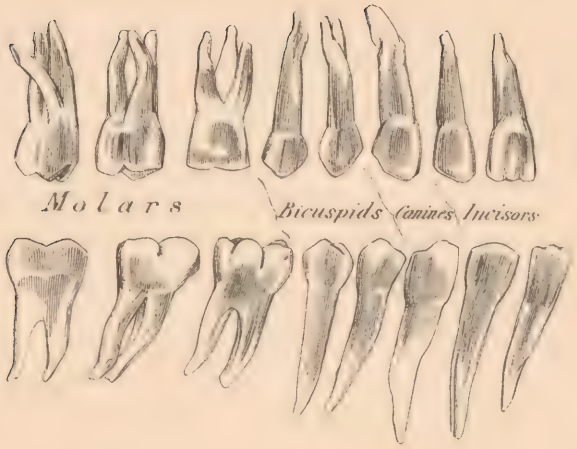


Fig 2



Fig 4

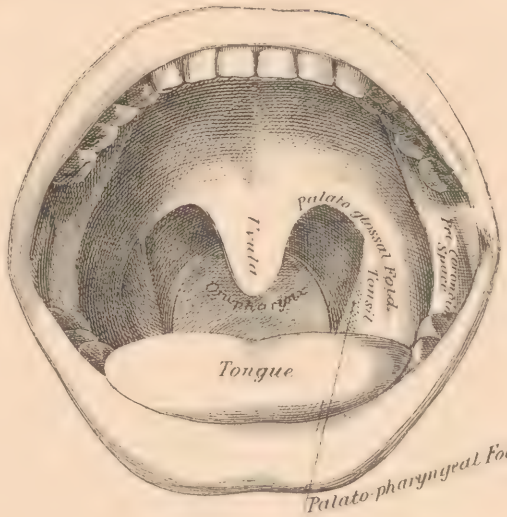
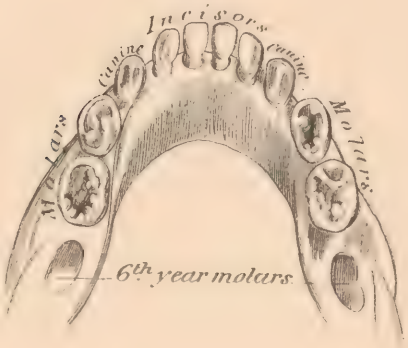


Fig 5



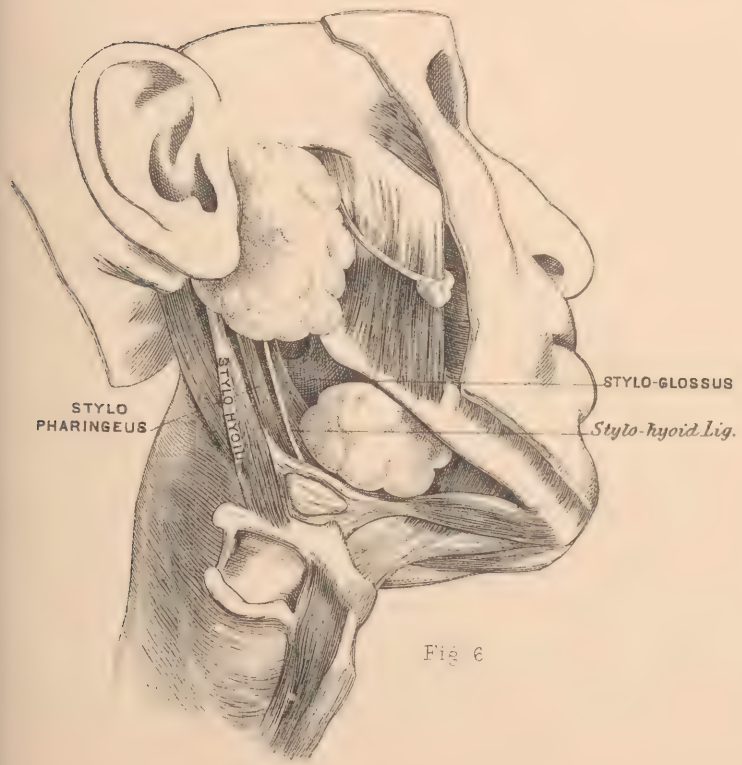
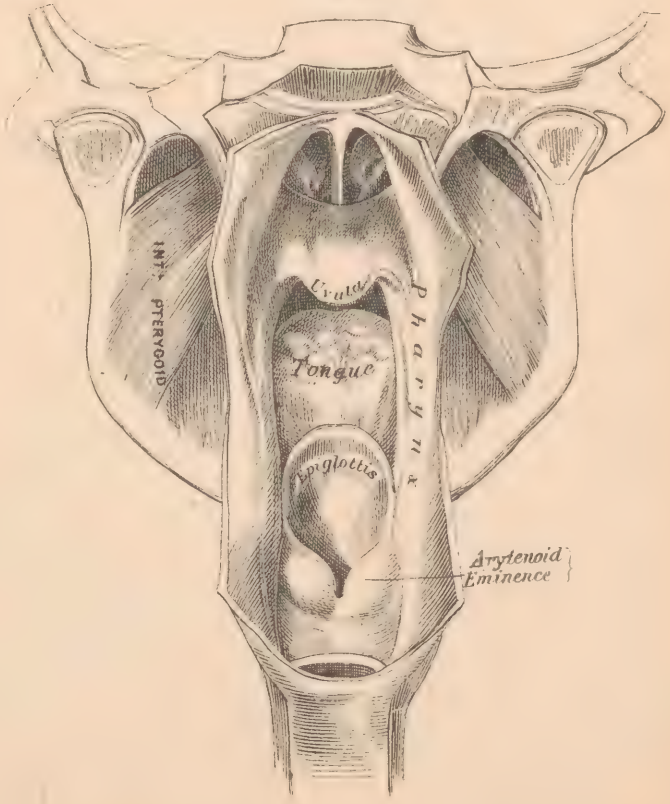


Fig 6

Fig 7



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Variations.—The pharynx, by localized weakness of its constricting muscles, may permit bulging of its walls, especially at its lower part. When such a bulging is pronounced it has received the name of the *pharyngeal pouch.* J. W. Ogle has described a case in which the pouch had attained the size of an egg. Mr. Dendy[1] states that the pouch usually dips down between the œsophagus and the vertebræ. An adventitious valve-like orifice distinguishes its junction with the pharynx. Great irritation may follow the retention of particles of food within it. In one case, as related by Mr. Dendy, the patient was compelled to fill the pouch with soft solid food before ordinary food could pass into the stomach. The contents of the pouch could be subsequently ejected.—The roof of the pharynx is occasionally the seat of congenital hairy outgrowths.[2]

THE SOFT PALATE.

The Soft Palate (velum palati, hanging palate) is a musculo-membranous valve appended to the posterior border of the hard palate. It stretches across the line of junction of the mouth and pharynx, but its posterior free border is projected into the pharynx, of which, indeed, it constitutes a part. Dependent from this border is a mobile, nipple-shaped structure called the *uvula.* At its origin the soft palate is fibrous; but the fibrous structure gradually disappears from before backwards, the posterior two-thirds of the soft palate being entirely muscular. The soft palate presents for examination one border and two surfaces,—an anterior and a posterior.

The border is thin and divided by the uvula into two crescentic portions.

The *anterior surface* is covered with a thick layer of racemose glands, which pour a viscid secretion into the mouth. The presence of these glands gives a yellowish tinge to this surface, and renders it free from folds.

The *posterior surface* is thin, and without glands, presenting a less closely adherent mucous membrane, which is apt to be faintly marked with minute transverse folds.

The soft palate receives the insertion of the Tensor Palati and Levator Palati muscles and gives origin to the Palato-Glossi, Palato-Pharyngei, and Azygos Uvulæ muscles. These structures more or less interlace in the substance of the velum.

Mechanism of the Soft Palate.—When at rest, as in expiration, the soft palate is held in its position (obliquely downward and backward) by two pairs of tractors, the Palato-Glossal and the Palato-Pharyngeal muscles. When elevated, as in inspiration, these muscles retaining their tensile power, the soft palate is acted upon by a pair of superior tractors, the Levato-Palati muscles. When it is raised, as in deglutition, or gagging, the process becomes more complicated. It is now initiated by the last-named muscles raising the muscular portion of the palate to a level with the aponeurotic portion. Succeeding this, the Palato-Pharyngeal muscles contract, elevate the pharynx, and tend to constrict its middle portion. This stage may be divided as follows: first, the elevation of the body of the soft palate, and the apposition of the hinder free end against the posterior wall of the pharynx. Secondly, the approximation of the Palato-Pharyngeal muscles, and the producing of the angle of their convergence toward the middle of the muscular division of the soft palate. Thirdly, the contraction of the uvular muscles. At the completion of the act the oro-pharynx is widened superiorly, while the tonsils, no longer seen in foreshortened profile, tend to be drawn deep within the oro-pharynx. The naso-pharynx is, of course, closed. The motions of the soft palate are indirectly influenced by the Pharyngeal Constrictors and the muscles of the Glosso-Hyoid series, and determine the patency of the Eustachian tubes. Within the range of their influence are the acts of breathing, swallowing, smelling, speaking, and sucking. If it be correct to say that those regions of the body are naturally defined which include muscles of the same related functions, it is seen that in the soft palate we have no unimportant structure, but the centre of a region of the mucous tract toward which converge muscles arising from such remote points as the base of the skull and the thyroid cartilage.

When the soft palate is elevated it can be readily determined by the use of the throat mirror that the naso-pharynx is virtually obliterated. The floor ascends, the lateral walls approximate each other, and the roof, by corrugation, projects the lymphoid structures downward. These actions can be referred to the Superior Constrictor muscle. Cleland[1] believes that the free upper edge of this muscle, by changing from a curved to a straight line, aids the Levator Palati in closing the orifice of the Eustachian tube.

Variations.—The uvula is sometimes congenitally divided in the median line. It is at times greatly elongated by disease, when it may serve as an exciting cause of cough. Hyrtl gives a whimsical account of a man who, having an attack of coughing, involuntarily caught the end of his pre-

[1] Prov. Med. and Surg. Journ., August 9, 1848.

[2] Journ. of Anat. and Phys., 1881, 244.

[1] Journ. of Anat. and Phys., 1868, 102.

ternaturally enlarged uvula between his teeth and bit it off, thus effecting a cure.—Among the variations of the soft palate may be appropriately included "cleft palate." For a consideration of this defect, see Teratology.—The structures of the soft palate are frequently asymmetrical, not, however, so frequently from congenital structural causes as from irregular actions of muscles, and from inflammatory invasion.

Remarks.—The clinical applications of a knowledge of the structure and uses of the soft palate are numerous. The soft palate is liable to syphilitic ulcerations. The ulcerated patches are often seen upon the posterior surface, where they exhibit a tendency to perforate the entire palate-structures. The ulcerated area is always larger posteriorly than anteriorly. The act of elevation of the palate brings the ulcer in contact with the posterior wall of the pharynx, and induces inflammation and ulceration of that portion of the pharynx with resultant stricture or atresia of the naso-pharyngeal orifice.[1]

Fibrous tumor of the soft palate is of infrequent occurrence. Mr. Kelbourne King[2] has described a case observed in a man twenty-eight years of age. The tumor had been growing for three months. It was situated on the left side, and entirely filled the oro-pharyngeal orifice. It projected upward into the naso-pharynx and thence into the nasal chamber. The growth was excised, but the patient died on the sixth day.

Hypertrophy of the glands of the soft palate is a slow process, and a period of from five to fourteen years is usually requisite for the development of a mass sufficient to obstruct the oro-pharynx. The mass may be contained in a separate compartment distinctly limited, spheroidal, and only very slightly connected with the adjacent parts, so that, when its capsule is excised, it may be easily enucleated with the finger.

Carcinoma of the soft palate is always medullary. It may begin somewhat after the same method adopted by the lingual cancer, viz., in first infiltrating the sub-epithelial cells.

In a case, narrated by Birkett,[3] a so-called polypus of the parts, in a man aged thirty-four, was excised, when cancerous infiltration ensued, and death followed nine months after the first appearance of the growth.

W. A. Love[4] has invited attention to the importance of inspecting the anterior surface of the hard and soft palate in the early stages of biliary catarrh. The icteric color appears in these localities earlier than in any other portion of the body.

W. H. Broadbent[1] has described two cases of paralysis of the soft palate in children, accompanied by regurgitation of fluids through the nose in attempts at deglutition. The tone of the voice was nasal and the articulation of sounds imperfect. The soft palate was seen to be pale, flabby, and motionless.

The palato-glossal fold. This fold often spreads out over the tonsil when the latter is engorged, or aids in defining a pocket between itself and the tonsil. A curved probe introduced into this pocket, and made to draw the fold forward, enables the observer to inspect it. It will often be found to contain pellets of tonsillar secretion. In some recognizable states of the tonsil, in which the pellets are too frequently formed, the breath becomes offensive. Under these circumstances the author has with benefit obliterated the fold by excision.

The palato-pharyngeal fold. In inflammatory infiltrations the pharynx often presents swellings along the borders of these folds, which may be mistaken for engorged tonsils.

In facial palsy involving the soft palate, the flaccid structure prevents efficient separation of the naso-pharynx from the oro-pharynx, so that food enters the nose during deglutition.

The *uvula* is convex at its base behind, and has thus a tendency to dispose the mucus descending from the nose to the lateral walls of the pharynx. An excessive flow of mucus is not confined to these normal conduits, but pours over the upper surface of the uvula. The uvula may be elongated, and excite cough by its intrusion within the laryngo-pharynx.

The mechanism of the soft palate has been carefully studied by examination of the living parts. This has been accomplished by inspection from below by the rhinal mirror in the normal subject, and by direct examination in cases of destructive ulceration of the soft palate from above;[2] also by J. Hilton[3] and Schuh,[4] through abnormal openings in the face, and by the aid of small mirrors inserted through the nasal chambers by Zaufal.[5]

Remarks.—The space between the pharynx and the vertebræ may be invaded by the products of dis-

[1] For cases with dissection, see W. Turner, Edin. Med. Journal, 1860, lv., 612.

[2] Lancet, 1871, 264.

[3] Trans. Path. Soc. London, 1860, xl., 233.

[4] Trans. Med. Assoc. Georgia, 1878.

[1] Trans. Clin. Soc. Lond., 1871, 92. [2] Cleland, Ibid.

[3] Guy's Hosp. Rep., i. 1836, 504.

[4] Wiener, Med. Wochenschr., 1858, No. 3; see in Med. Times and Gaz., xix. 1859, 357.

[5] Archiv für Ohrenheilkunde, x. 1875, 133; see, also, a paper by the author in Trans. Col. of Physicians of Phila. 1884.

ease either from the vertebral or the pharyngeal side. The disease known as *post-pharyngeal abscess* or *retro-pharyngeal abscess* is thus located.

The pus in such a collection pushes the posterior wall of the pharynx forward, causing dysphagia. Sometimes it gravitates and forms deep collections of pus in the neck. In a case of this description, carefully reported by Hilton,[1] a large deep swelling occupied the upper part of the left side of the neck as far as the angle of the jaw. The carotid artery was felt pulsating upon the anterior aspect of the swelling, close to the anterior edge of the Sterno-Cleido-Mastoid Muscle. The trachea was pushed forward and to the right side. The collection was opened through the Sterno-Cleido Mastoideus. The patient, a child of twelve months, recovered.

When a pharyngeal abscess is about to burst within, a projection often forms which has been known to press upon and obliterate the aperture of the glottis.[2]

The tonsil and the adenoid tissue at the roof of the pharynx (pharyngeal tonsil) tend to disappear after the completion of the process of ossification of the skeleton.

The pharynx is furnished with numerous follicular and racemose glands. These are most conspicuous along its posterior wall, where they frequently form enlarged lentil-shaped out growths due to the thickening of the connective tissue about their ducts. Such eminences when numerous form one of the most distinctive signs of follicular pharyngitis.

The naso-pharynx. The adenoid tissue at the roof of the pharynx is sometimes greatly enlarged, and occupies the naso-pharynx, interfering with the action of the soft palate.[3]

The naso-pharynx is the seat of a peculiar tumor known as fibrous polypus or naso-pharyngeal polypus. It appears to originate at the lateral aspect of the roof, and tends to grow downward and forward into the nose and its connections. It may, however, break down by pressure thin barriers of bone, as the walls of the sphenoidal sinus, the plates of the ethmoid, and other thin facial bones.

Epithelial cancer of the pharynx has been described by Sydney Jones.[4] A pendulous fatty tumor is described and figured by Holt.[5]

[1] Lectures on Rest and Pain.

[2] Peacock, Trans. Path. Soc., i. 1849, 88.

[3] For a detailed account of this condition, see Meyer, Med.-Chir. Trans., 1870, 191.

[4] Trans. Path. Soc. Lond., 1860, xi. 101.

[5] Ibid., 1854, 123.

The recess on the lateral wall of the pharynx between the orifice of the Eustachian tube and the posterior wall, is called the fossa of Rosenmüller.

This fossa is used as a guide by the physician in introducing the Eustachian catheter. By first inserting the end of the instrument in this depression it can be felt by gentle traction forward to leave the fossa, glide over the hook-cartilage of the Eustachian tube, and drop into its orifice. The physician is thus reasonably certain of securing the desired object without the necessity of recalling the varying relation of the orifice of the tube to other fixed points of the naso-pharynx.

The pharynx when perforated (as by a fish-bone or projectile) may lead to diffuse suppuration in the neck and to exposure of the basilar process of the occipital bone. Extravasation may take place through this opening in the roof of the pharynx and cause abscesses in various parts of the neck.

A unique case is narrated by Ch. H. Moore[1] of perforation of the pharynx by the superior cornu of the thyroid cartilage, caused by a fall from a horse. Extensive suppuration of the neck followed, and the patient perished at the end of two months. Cases have also occurred in which fragments of straw have perforated the pharynx, causing abscess and extravasation.

Division of the lower part of the pharynx often accompanies lesion of the larynx in suicidal cut-throat. The act of deglutition is necessarily interfered with, the lips of the wound separate at each attempt to swallow, and liquids may even run out of the wound upon the skin of the neck.

THE TONSIL.

The Tonsil (fig. 2, Plate C.) is an almond-shaped body, about nine lines long and six lines wide, lodged in the space between the palato-glossal and palato-pharyngeal folds. This space from the disposition of the folds is narrow above where they converge, and broad below, where they diverge. Hence the tonsil is in contact with the folds above, but is free below. To the outer side of the tonsil lies the Superior Constrictor muscle and beyond this are found the internal carotid artery and the lower portion of the parotid gland. Extending downward in the tonsillar space below the tonsil are scattered a few pea-shaped bodies which resemble the tonsil. These form the infra-tonsillar glands (*cryptæ vestibuli inferiores* of Tour-

[1] Lancet, 1864, 286.

tual). They are sometimes when engorged the exciting cause of cough by pressure against the base of the tongue.

The tonsil is a glandular structure having a fibrous matrix which affords accommodation for numerous small closed sacs. These are for the most part arranged along the borders of irregular sinuous depressions which open upon the median free surface of the pharynx; the orifices are from fifteen to twenty in number.

Remarks.—In operations upon the tonsil, such as excision for hypertrophy and incision for abscess, the relation it bears to the internal carotid artery should be remembered. In opening an abscess of the tonsil the bistoury should not be thrust outward. Neglect of this precaution has led to serious complications from bleeding of the wounded structures. The internal carotid artery has thus been opened with fatal results. In cancerous infiltration of the parotid gland, the disease has extended by contiguity to the lateral wall of the pharynx and thence to the tonsil.—The tonsil when engorged may project into the pharynx and tend to obliterate the inter-tonsillar space, the symptoms being for the most part those pertaining to disordered respiration and deglutition. If, however, it enlarges without this median projection, the pressure forward and outward provokes difficulties of mastication, and possibly of hearing. Upward pressure of an engorged tonsil can scarcely fail to push the soft palate upward, and by that means to maintain closure of the orifice of the Eustachian tube when the mouth is closed.—The tonsil may be tightly held by the folds on either side, in which case their division has been recommended.—In the second part of the act of deglutition the tonsil is pulled toward the posterior wall of the pharynx. Sometimes the surface which usually projects medianly is turned directly backward. Under these circumstances interference with the proper accomplishment of deglutition acts as an exciting cause of disease.—The tonsil, even when not enlarged, may be the cause of persistent irritation if the tonsillar tissue is indurated and lies concealed between closely approximated folds.

Tonsillar abscess usually terminates, if not opened by the knife, by a spontaneous opening into the cavity of the pharynx. Instances are known, however, of rupture of the abscess through the fibres of the Superior Constrictor muscle into the pterygo-maxillary region.[1]

It is rational to assume that the overgrowth of the tonsil is an attempt at compensation on the part of an organ engaged in manufacturing blood-corpuscles, when other blood-making structures, such as the medulla of bone, are inactive. The tonsils, if of sufficient size to interfere with oral respiration, should be excised. If, however, they are simply enlarged and do not interfere with respiration, they should be let alone.—The tonsil may become hypertrophied to such a degree as to be felt beneath the skin at the angle of the jaw. In common with other closed gland-structures the tonsil is very rarely the seat of primary malignant growths.

THE ŒSOPHAGUS.

The Œsophagus (gullet) is that portion of the alimentary canal which extends between the pharynx and the stomach. It begins at a point opposite the cricoid cartilage or the fifth cervical vertebra and ends at the cardiac orifice of the stomach opposite the ninth, tenth, or eleventh dorsal vertebra, and measures from nine to eleven inches in length.

The œsophagus is the narrowest portion of the alimentary canal, and in a state of rest is slightly flattened as well as contracted, its mucous membrane being thrown into longitudinal folds so that a transverse section exhibits a stellate oval figure. It is slightly narrowed in passing through the Diaphragm and at the beginning of the thoracic portion. It is, at the latter place, but one inch in diameter. Sappey compares the canal to two elongated cones whose apices join at the last-mentioned constriction.

[1] Reitch, Anatomie Chirurgicale, 416.

EXPLANATION OF PLATE C.

Fig. 1. A diagrammatic representation of the arrangement of the peritoneum.

Fig. 2. The posterior wall and roof of the naso-pharynx, designed to display the adenoid tissue.

Fig. 3. The tonsil.

Fig. 4. The organs of the abdomen *in situ*, in repletion of the stomach; normal.

Fig. 5. The organs of the abdomen *in situ*, in inanition. Drawn from the body of a young woman who died of phthisis pulmonalis.

Fig 1

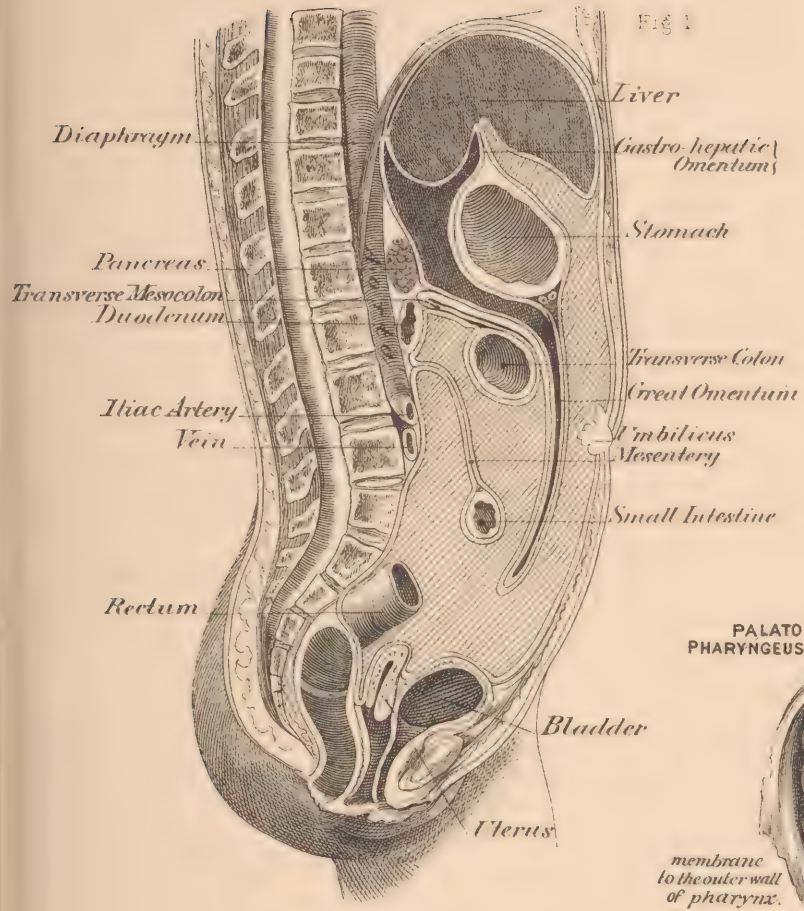


Fig 2



Fig 3

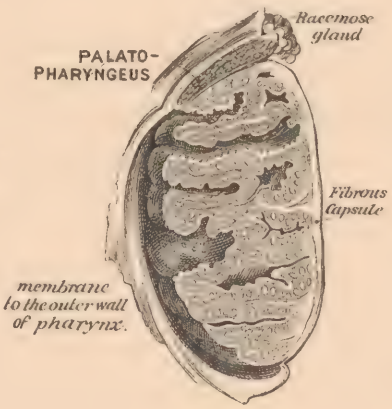


Fig. 4.

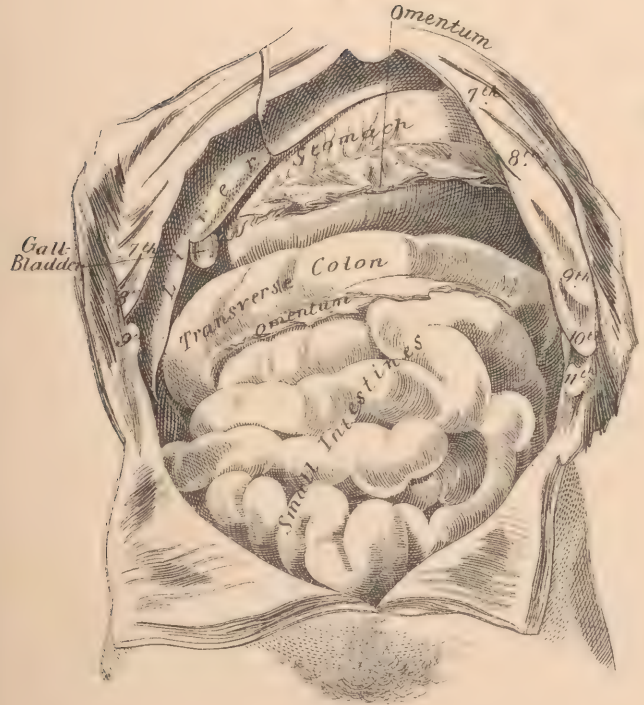
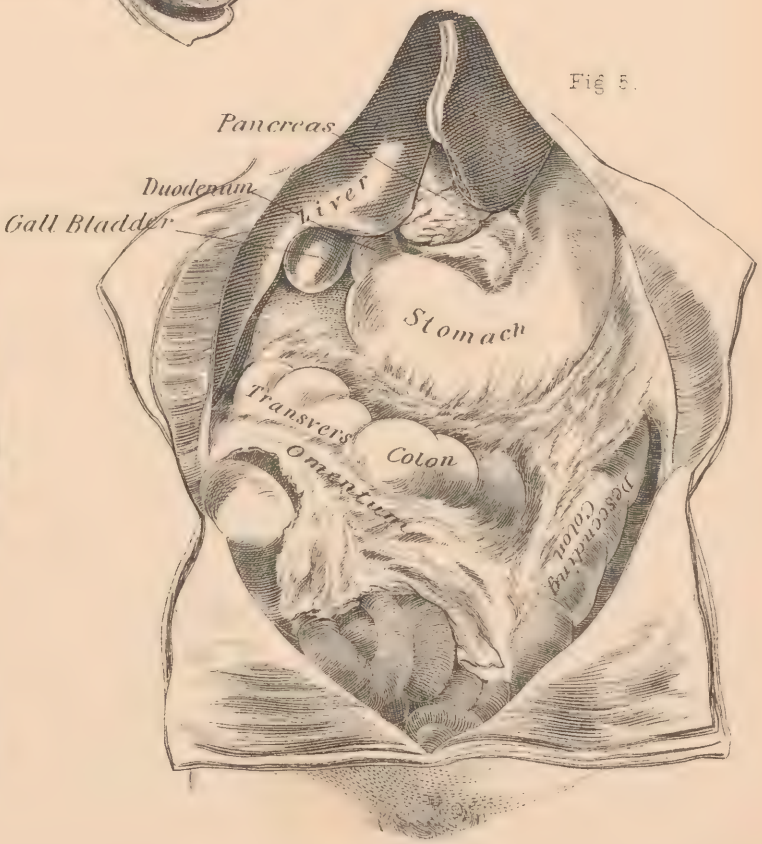


Fig 5.



T. Sinclair & Son, Lith.

The œsophagus is composed of a muscular, a submucous, and a mucous coat. The muscular coat presents two layers: an outer (longitudinal) and an inner (circular). The longitudinal layer arises from the posterior median ridge of the cricoid cartilage, and at the sides is continuous with the fibres of the Inferior Constrictor muscle, and is divided into three fasciculi, one in front, and one on either side of the gullet. These unite at the lower part of the canal, and finally are lost upon the walls of the stomach in the longitudinal fibres of that organ. The circular fibres, which are continuous with the lower fibres of the Inferior Constrictor of the pharynx, are slightly thicker than the longitudinal.—At several points on the posterior surface of the canal, the longitudinal fibres are entirely absent.—The muscular portions of the œsophagus in the cervical region are composed of striated muscular fibre; throughout the remainder of its course, of the non-striated variety. In addition to the muscular layers, as above given, Luschka describes several fasciculi which arise from the inferior horn of the thyroid cartilage.

The œsophagus is remarkable for possessing several muscular slips which extend from the canal to different organs. Attention was first directed to these fibres by Hyrtl,[1] who describes a *broncho-œsophageal slip* which arises from the œsophagus and is inserted into the posterior membranous wall of the left bronchus, and a *pleuro-œsophageal slip* which arises from the left wall of the œsophagus and is inserted into the left wall of the mediastinum. Treitz has detected similar fasciculi passing to the pericardium, to the trachea, and to the great vessels.

J. D. Cunningham[2] has found as the result of fourteen dissections that pleuro-œsophageal muscular filaments were present in thirteen subjects, and pleuro- and broncho-œsophageal muscular fibres in ten. He has noticed muscular fasciculi passing from the anterior surface of the œsophagus to be inserted into the pericardium.

The submucous layer of the œsophagus is abundant, and permits the mucous membrane upon it to be easily raised in folds. The mucous membrane is of a yellow or grayish-red color and is covered with squamous epithelium. At the lower third, racemose glands with well-defined ducts pass through its entire thickness.

Relations and Remarks.—The œsophagus describes three curvatures: one, the antero-posterior curvature which answers to the curvature of the vertebral column; and two lateral curvatures. The *first lateral curvature* lies a little to the left of the median line, and terminates just below the origin of the left bronchus. From this part the *second lateral curvature* extends, which again carries the œsophagus a little to the left of the median line, but brings it at the same time forward so as to terminate at the œsophageal opening of the Diaphragm. The first lateral curvature secures its most important relation with the trachea, which may be said to determine its position; the second retains its most important relation with the aorta; the first might therefore be called the *tracheal* curvature, and the second the *aortic*.

Viewing the relations more exactly, the œsophagus is seen to lie first behind the trachea, then to appear at its left side near the base of the neck. Adjacent to it lie the left carotid artery and the left lobe of the thyroid body, together with the pneumogastric and left recurrent laryngeal nerves. Behind it, separated by loose connective tissue, is the Longus Colli muscle. Within the chest the pleura is in contact with it on either side. It is crossed by the left bronchus as this structure passes obliquely downward and outward at the level of the fourth or the fifth dorsal vertebra, and lies behind the pericardium, where that membrane covers the left auricle. Just as it leaves the region of the left bronchus the œsophagus assumes relations with the aorta in the neighborhood of the fourth costal cartilage. It first lies a little to the right of the aorta, and then, *i. e.*, at about the lower third of its course, it lies in front of the vessel and to the left. It then describes an extended sinous line about the aorta. To the right and behind it lies the azygos vein. Parallel with it are the pneumogastric nerves; the left nerve passing in front, and the right nerve behind the œsophagus.

Instances are on record of hemorrhage into the œsophagus from the superior vena cava, from the ascending portion of the aorta, and from the innominate or right subclavian arteries. The heart has also been wounded by a foreign body which had lodged first in the œsophagus.

The relations of the tracheal curve are essentially different from those of the aortic curve. In the tracheal, the œsophagus is, relatively speaking, firmly held between the respiratory passages and the vertebral column, and is subject to no considerable deviation from its normal line; but the aortic curve varies in its position with the movements of the thoracic viscera. It is described as lying to the left of the front of the aorta, but it may, if the liver is small and depressed, while the stomach or spleen is enlarged and elevated, lie directly in front or even to the right of the aorta.

[1] Zeitschrift der Wiener Aertze, 1844.

[2] Journ. Anat. and Phys., 1876, 320.

The aortic curve of the œsophagus must be also regarded as a result of the ascent of the Diaphragm accompanying gastric repletion or similar conditions. Above the point at which the left bronchus crosses the œsophagus, an upper tract may be defined which is liable to invasion by diseased conditions from without, or to obstruction within; while the lower portion is free from any liability to outward pressure or internal occlusion. Out of nine cases examined with the object of determining at what point in the œsophagus foreign bodies may lodge, in seven the author has found that the obstruction existed in the tracheal curve, and in two only in the aortic. In both of the latter, the foreign substances were spicules of bone, and the cases presented unusual features.[1]

It may be said that the region of the left bronchus and the region of the cricoid cartilage are favorite places, not only for the lodgment of foreign bodies, but for the initiation of diseased action. Thus, out of forty cases of disease examined, eight only appear to have been located elsewhere. Of the remaining thirty-two, ten were situated at the cricoid, twelve at or near the left bronchus, and ten were found in which the disease, while below the left bronchus, indirectly involved that structure.

The following table may be found convenient: Length of the œsophagus, ten to eleven inches:—

The distance from the upper border of the cricoid cartilage to the tracheal bifurcation is from four and a half to five inches.

The distance occupied by the left bronchus in crossing the œsophagus is about an inch.

The distance from the left bronchus to the cardiac orifice of the stomach is from four to five inches.

The end of the aortic arch is at about the third dorsal vertebra.

From the incisor teeth to the cardiac end of the stomach, fifteen to sixteen inches.

From the incisor teeth to the left bronchus, from ten to ten and a half inches.

From the incisor teeth to the upper edge of the arch of the aorta, nine inches. To the lower edge of the same, ten to ten and a half inches.

The following conclusions are drawn from the foregoing statements:—

(1) Foreign bodies are liable to be retained at the beginning of the œsophagus behind the cricoid cartilage.

(2) Passing this point, they do not, as a rule, reach the cardiac end, or "lower part," but are apt to be lodged just above the left bronchus as it crosses the œsophagus.

(3) The cricoid region is exceedingly liable to invasion, and if the disease extends thence downward it is often limited by the left bronchus.

(4) It is probable that diseased action may occasionally originate at the point of greatest narrowing of the thoracic portion, viz., just below the superior thoracic aperture.

(5) The region of the left bronchus is very frequently attacked, the disease commencing either behind or just below it, and extending thence downward.

(6) The cardiac end of the œsophagus is less frequently attacked than either the cricoid or bronchial portions.

(7) Resistance at or near the left bronchus can be detected by a probang meeting resistance at eleven inches from the incisor teeth.

(8) The dangers attending the forcible use of the probang below the region of the cricoid become more manifest when the relations of the left bronchus are borne in mind.

Variations.—The œsophagus may unite with the trachea at a point about midway between the lower border of the cricoid cartilage and the point of origin of the bronchi. Answering to some portion of the œsophageal tract as it lies behind the trachea the œsophagus may be reduced to a small tube (atresia œsophagi) and afterward be abruptly dilated to its normal size.—The lower end of the œsophagus may be dilated

[1] See Memoir by author, Phila. Med. Times, 1877.

EXPLANATION OF PLATE CI.

Fig. 1. The muscular layer of the stomach.

Fig. 2. The stomach, seen from without.

Fig. 3. The lower end of the rectum and the margin of the anus. The right third of the figure exhibits the mucous membrane dissected from the submucous connective tissue, the veins, and the internal sphincter muscle-fibres.

Fig. 4. The structure of the male pelvis displayed by a transverse vertical (frontal) section, and seen from behind.

PLATE CI

Fig 1



Fig 2

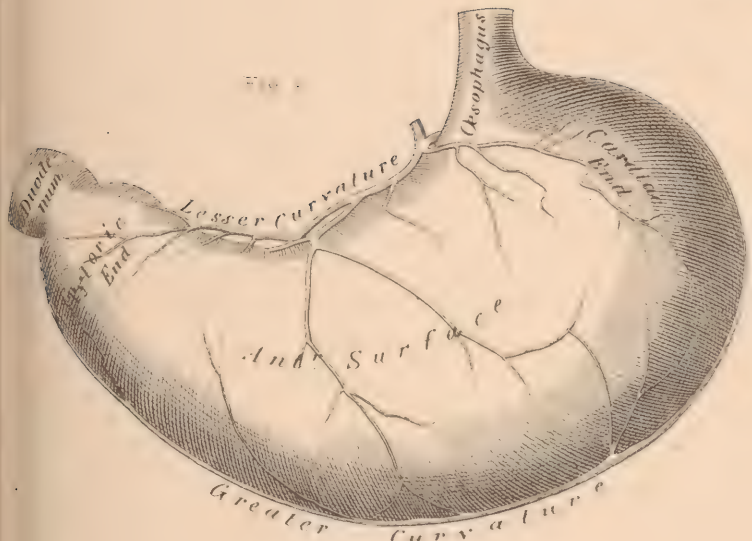


Fig 3

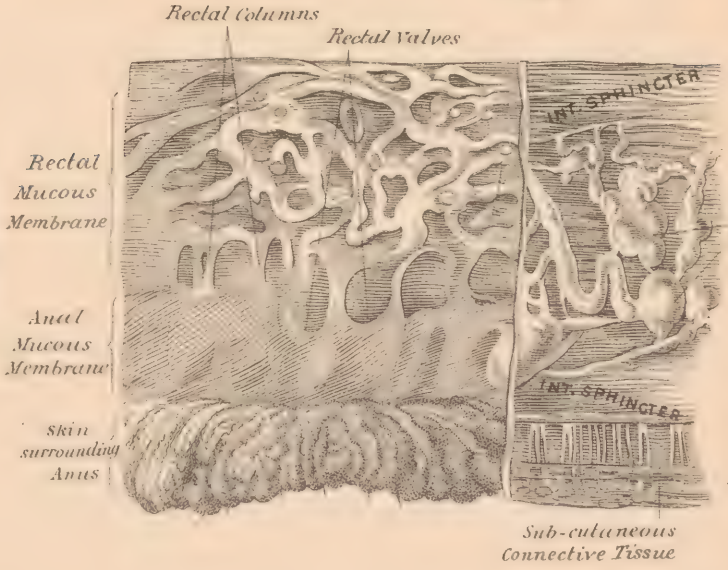
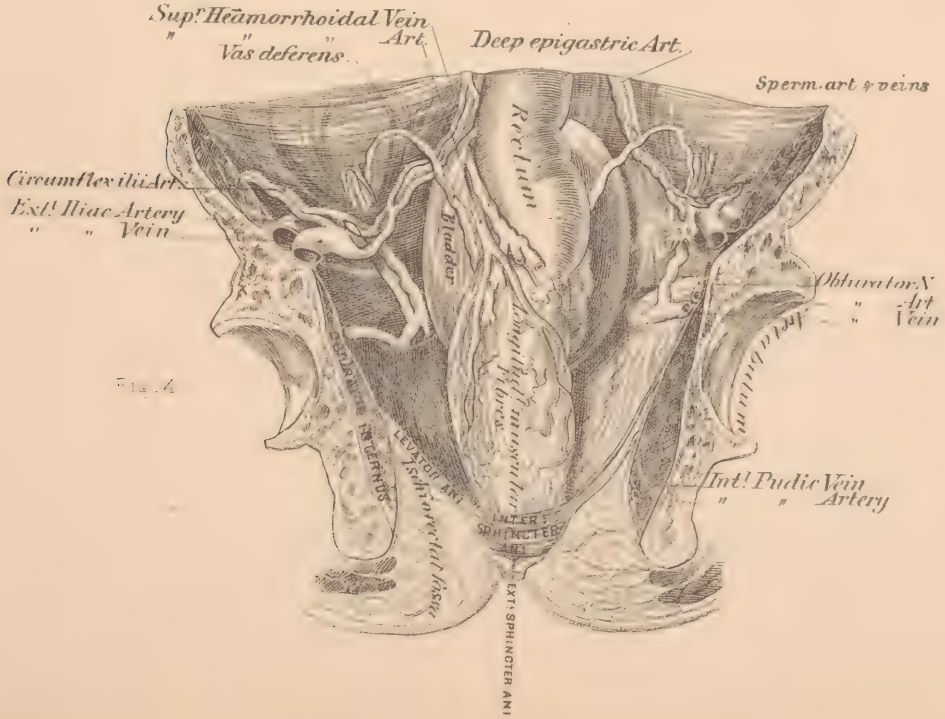


Fig 4



so as to form a chamber antecedent to the stomach—an arrangement which is suggestive of the proventriculus of the bird. Luschka refers to the case of a man who actually ruminated by means of an enlargement of this character.—Of great rarity are examples of duplication of the œsophagus.—The œsophagus and the aorta may pass through the Diaphragm together.

Bloodvessels.—The œsophagus is supplied by the œsophageal branches of the aorta.

The *veins* are tributary to the intercostal veins, and to the hemiazygos and azygos vein.

Bristowe[1] has found hemorrhages from varicose veins lying beneath the mucous membrane to be the exciting cause of death in a case of ulceration of the œsophagus.

Nerves.—The nerves of the œsophagus are derived from the anterior and the posterior œsophageal plexuses of the pneumogastric nerves.

Lymphatics.—The lymphatics pass to glands lodged in the posterior mediastinum.

THE STOMACH.

The Stomach (figs. 1, 2, Plate CI. 4, 5, Plate C.) is that portion of the alimentary canal designed for the reception of food during the first stage of digestion. It is a retort-shaped sac, placed between the œsophagus and the duodenum. It is the most expanded portion of the alimentary canal, and though its size is necessarily subject to great variation, it may be given as follows, viz.: length, 9 to 12 inches; diameter, 4 to 5 inches; greatest circumference, 13 inches; least circumference, 3 inches; vertical measurement at cardiac end, 11 inches; weight, 4 to 4½ ounces; capacity, about 62 fluidounces.

This organ is slightly smaller in the female than in the male. The base, or most expanded portion, is called the *fundus* (cardiac extremity). The narrowed portion for about three inches from its termination in the duodenum is called the *antrum pylori*, and presents a slightly swollen appearance, as its borders somewhat disturb the regularity of the contour of the entire organ. The point of communication with the gullet is the cardiac orifice, which is placed several inches to the right of the fundus. The communication with the duodenum is called the *pylorus* (pyloric orifice). The shortest curvature between these orifices is called the *lesser curvature;* the longest curvature between them is called the *greater curvature.* The two curves as they approach the antrum pylori undergo a change in form, both presenting a wavy contour as they define the upper and lower wall of the pylorus.

The stomach is situated in the epigastric and left hypochondriac regions, a small portion only of the pyloric extremity projecting into the right hypochondriac region. It is estimated that five-sixths of the stomach lie to the left of the median line and one-sixth lies to the right.

Relations.—Above the stomach are the Diaphragm and the left lobe of the liver; below is the transverse colon. To the right is the spleen; to the left is the liver; in front is the abdominal wall; behind are the pancreas, the portal and superior mesenteric veins, and in part the spleen and great vessels. The cardiac end lies above the left kidney.

The exact relations are of necessity modified by the condition of the stomach, whether full or empty. When *empty*, the organ is nearly perpendicular, the lesser curvature being almost continuous with the gullet, the pylorus depressed, and the two curvatures disposed to the right and left. When the organ is *full*, it rises so as to present its lesser curvature posteriorly and its greater curvature anteriorly. The pyloric end is near the anterior abdominal wall, and is more mobile than the cardiac end, which is fixed by a fold of peritoneum called the gastro-phrenic ligament. For additional relations see Remarks.

According to Sibson, the cardiac orifice of the stomach is situated to the left of the ninth and tenth dorsal spines. A small portion of the fundus lies between the base of the left lung (the Diaphragm alone intervening) and the supra-renal capsule. This exposed portion of the stomach is, however, covered by the lung, when the left base descends so as to be interposed between the surface and the supra-renal capsule.

The attachments of the stomach are as follows: 1. A relatively strong doubling of peritoneum extending from the Diaphragm to the lesser curvature of the stomach called the gastro-phrenic ligament (*supra*). 2. A thin broad fold passing from the pyloric end to the transverse fissure of the liver, called the lesser or gastro-hepatic omentum. 3. A short fold between the cardiac extremity and the spleen,—the gastro-splenic fold. 4. A fold from the greater curvature to the colon,—the gastro-colic fold.

Structure.—The stomach is described as having four coats, named in their order from without inward the serous or peritoneal, the muscular, the submucous or areolar, and the mucous.

[1] Trans. Path. Soc. London, 1857, 175.

The *serous coat* (peritoneal coat) is complete except at the curvatures, where a space exists for the accommodation of the gastric vessels.

The *muscular coat* is composed of three sets of fibres: the external layer, the middle, and the internal. The *external* layer (longitudinal) is the strongest. It presents a general covering to the organ, and is best developed along the lesser curvature. Its fibres are continuous with the longitudinal fibres of the œsophagus. The fibres of the middle layer (circular layer) are arranged in loops like figures of 8 across the short circumference of the organ. They are stoutest at the pyloric end, where they almost entirely inclose and define the pyloric sphincter, being directed toward the pyloric axis. The pyloric orifice, therefore, is an annular ring of muscle-fibres of the middle layer covered with mucous membrane. The fibres of the *middle* of the stomach are continuous with the corresponding fibres of the œsophagus. The *internal* layer (oblique layer), the weakest of the three, is composed of a loop or ribbon-like fold of fibres lodged behind the cardiac orifice. From this locality the fibres radiate, the upper ones being directed toward the lesser, and the lower toward the greater curvature. The upper end of the band is better defined than is the lower. It is thought by late observers that this set of fibres is not continuous with the œsophagus, as was formerly supposed. Retzius[1] states that the muscular fibres of the stomach, particularly those of the oblique set, contribute to form at the lesser curvature a groove opening toward and continuous with the gastric cavity, which serves as a guide for fluids to flow from the œsophagus directly to the pylorus, without mingling with the contents of the stomach. This arrangement is in harmony with that seen in the sacculated and compound stomachs of many animals.

The *submucous coat* is a thin layer of connective tissue intervening between the muscular and mucous coats. It is chiefly interesting from the fact that the loose connection of the mucous with the muscular layer is due to it.

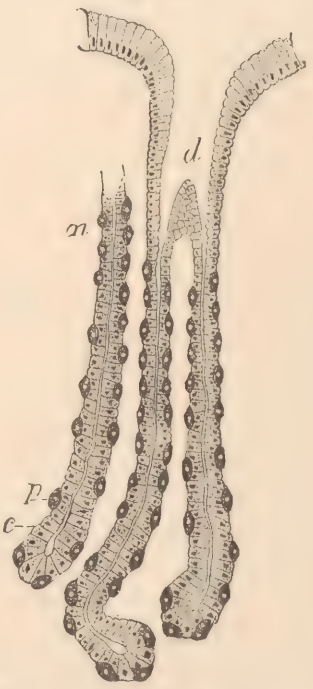
The mucous coat is thicker toward the pylorus than elsewhere, and in the empty organ is marked by longitudinal folds or rugæ, which, however, disappear when the viscus is distended. These folds are most conspicuous toward the pylorus, and along the greater curvature, while they are nearly or entirely absent from the fundus. The mucous membrane lining the pyloric sphincter may receive the name of the *pyloric valve*. This membrane is of a pale pinkish or red-brown color; it is thickest toward the pylorus, where small villoid structures are seen. It varies from three-quarters of a line to one line in thickness. Connecting the longitudinal folds are others, placed at right angles, which give the mucous surface a coarsely reticulated appearance. Within the spaces thus formed are seen numerous small pits or alveoli which measure one-hundredth to two-hundredth of an inch in diameter. The alveoli are studded with the orifices of the *peptic glands* (gastric follicles). In addition to these structures the entire surface is marked with minute elevations (mamellæ); these are due to the presence of closed or lenticular glands, and are best seen in the stomachs of infants and children.

The epithelium of the stomach is of the columnar variety. The epithelium of the mucous membrane of the œsophagus terminates at the cardiac orifice abruptly by a well-defined but irregular border.

Extending between the serous and muscular layers are a few longitudinal fibres which may be named the *ligamentum pylori*.

The Glands of the stomach are of the tubular variety, and extend vertically or in slightly tortuous lines through the entire thickness of the mucous membrane, being smallest where the membrane is thinnest, as at the cardiac extremity; and largest and at the same time more numerous where the

Fig. 174.



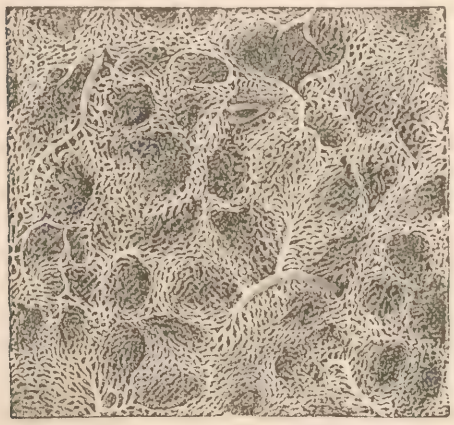
The appearance of the peptic glands under a low power; *d*, duct; *n*, neck; *p*, parietal cells; *c*, chief cells.

[1] Archiv fur Anatomie, 1862, 136.

membrane is thickest, as toward the pylorus. The glands have an average diameter of five-hundredth to three-hundred-and-sixtieth of an inch. The entire number of glands in the stomach is estimated by Sappey to be 4,900,000. Each gland ends either simply, or by one, two, three, or even four divisions. The most complex of these are situated toward the pyloric extremity. The glands may be divided into two groups, which are distinct in details of structure. The first group, called the *muciparous*, or *pyloric* glands, possess wide mouths, and are lined with columnar epithelium similar to that found elsewhere on the gastric mucous membrane. The deep tubular portions of the glands are lined with cubical granular cells. The second group, called the *peptic* or *cardiac* glands, are lined along the duct-like portions with columnar cells, while the fundus and the portion directly above it are furnished with short columnar or polyhedral cells (*c*, Fig. 174, *principal cells*, chief cells, central cells), having free nuclei, and granules. Lying between the principal cells and the basement membrane are a number of larger oval cells (*p*, Fig. 174), which have received the name of the *parietal cells* (superadded cells).

The tubular glands near the pylorus occasionally incline to the racemose type.

Fig. 175.



Appearance of the lining membrane from the cardiac extremity of the stomach, in an injected preparation.

Bloodvessels. Arteries.—The arteries of the stomach are the left and right coronal, the right and left gastro-epiploica dextra and sinistra, and the short gastric arteries.

Veins.—The veins are tributary to the portal vein, the mesenteric vein, and the splenic vein.

Nerves.—The nerves are derived from the anterior gastric plexus from the left pneumogastric nerve; and the posterior gastric plexus from the right pneumogastric nerve. Sympathetic nerves are derived from the cœliac plexus.

Lymphatics.—The lymphatics join the cœliac glands.

Variations.—The stomach is sometimes found temporarily narrowed transversely at a point midway between the cardiac and pyloric ends by over-action of the circular muscular fibres at the point of constriction. Albers[1] figures an example of a permanent constriction of the stomach which served to divide the viscus into two chambers or sacculations. This arrangement permits comparison to be made between it and the condition normally present in the kangaroo.

Remarks.—The stomach in the fœtus is nearly vertical by reason of the two nearest fixed points of the alimentary canal, viz., the œsophagus at the Diaphragm, and the terminal portion of the duodenum, being in a line but slightly deflected from the perpendicular. Coincident with the dilatation of the lower side of the organ, it becomes more obliquely placed, and the narrowed or pyloric end is carried to the right.

These changes may be advantageously borne in mind in comparing the empty with a full stomach (figs. 4 and 5, Plate C.). In *fasting*, the pyloric end of the stomach falls, and the entire organ is placed very obliquely if not nearly vertically in the abdomen. In a word, it tends to return to the fœtal or unused position. The fundus lies high up in the left hypochondriac region. The curvatures of the organ are scarcely apparent. The pylorus does not touch the liver, but lies near or upon the vertebral column at the level of the eleventh dorsal vertebra (Braune). The transverse colon lies across the organ, or may even be above it, when it will lie in contact with the Diaphragm (Hyrtl). In this event some coils of small intestine are apt to be associated with it. Hence the distressing flatus of some forms of anorexia, and the pain which is referred to the "side," *i. e.*, left hypochondriac region, by anæmic females.

The prolapse of the pyloric end in the adult when the stomach is empty is due to two causes: first, the increased weight of this portion of the viscus; second, the suspension of the organ by the œsophagus at the cardiac end. When the stomach is habitually collapsed, the pylorus always lies below the plane of its normal position, and differs but slightly in appearance from the first portion of the duodenum, and may, as in a case reported by J. W. Trotter,[2] extend to a point one inch below the anterior superior

[1] Atlas der Path. Anat., iv., Taft I. fig. 1.
[2] Trans. Path. Soc. Lond., iii. 318.

spinous process of the ilium. Hence the facility with which in such subjects duodenal regurgitation may occur. It is unnecessary to resort to the supposition of tight-lacing, as has been done by some writers, to account for the prolapsus of the pylorus in anæmic persons.

One of the most important *indirect relations of the pyloric extremity* is entered into by the head of the pancreas. When enlarged by cancer this portion of the gland may press against the pylorus and almost obliterate it.[1] Cancerous infiltration of the pylorus, by increasing its weight, may draw this portion of the stomach further down in the abdomen than is normal, viz., as far as the eleventh dorsal vertebra, opposite the umbilicus, or as above stated to a point near the ilium. It is apt, moreover, to become superficial, by reason of the inflated condition of the first portion of the duodenum, whose relations are necessarily disturbed by the descent. As a result a tumor answering to the cancerous mass may often be felt through the abdominal walls.

In *repletion*, the stomach, besides becoming transverse to the vertical axis of the trunk, advances in front by increased dilatation of the lower side of the organ. The fundus occupies almost entirely the left hypochondriac region. An instrument penetrating the sixth, seventh, eighth, or the ninth left intercostal space would enter it. The pylorus is raised and deflected to the right—lying about two inches and three-quarters from the median line. The curvatures of the entire organ are pronounced, and the greater one advanced forward. The transverse colon lies below the stomach, while the pancreas lies directly behind it, and, in the opinion of Hyrtl, is compressed by it, so that an outflow of pancreatic secretion is assured. At the same time it would appear that the vessels accompanying the pancreas are free from pressure since they lie along the upper border of the organ. The common bile duct and portal vein are also free from pressure.

When a tumor, which has been detected in the position above indicated, can no longer be outlined, and its site is occupied by a tympanitic surface, it is probable that the transverse colon has descended from its usual high position, and is lying directly in front of the indurated mass.

The stomach may assume *proportions* greatly in *excess* of those stated above as normal. The superior curvature has been known to measure 37¼ inches.

In the operation of gastrotomy the organ will be found distended to an enormous extent—if the obstruction lies below the pylorus—but contracted and in the position of fasting if the obstruction is œsophageal.

In extreme degrees of distension the stomach presses upward against the Diaphragm, and laterally against the lower ribs. It thus interferes with a free respiratory movement, and disturbs the action of the heart. Hence the palpitation in prolonged or excessive gastric repletion, and the reference of the sensations of dyspepsia to the region of the heart.

The *effects of respiration* upon the stomach are briefly as follows: The pylorus is lowered by a forced inspiration to the level of the umbilicus. The cardiac orifice is drawn downward by the crura of the Diaphragm for about one inch.

An application may here be made of the *law of localization of diseased action*, viz., that parts enjoying the most rest are least liable to involvement by structural disease. Out of 220 instances of gastric ulcer collected by W. Brinton, but 4 were found in the cardiac pouch, while 32 were found in the pyloric end. It is not so easy to explain the occurrence of 86 ulcers on the posterior surface, and 56 on the lesser curvature, while 10 only were met with on the anterior surface, and 5 on the greater curvature. It is probable, in view of these striking contrasts, that the lesser curvature and posterior surface have much in common, and that they are in a condition of greater functional activity during digestion, or are subjected to greater strain by the change from the empty to the distended position.

During the gradual *process of restitution* which is effected after every meal, the muscular coats of the stomach contract. Should this contraction be irregular, a constriction will often take place about midway between the extremities; this, when persisting after death, has received the name of the hour-glass constriction. (See Variations.) When the contraction is very marked, it is associated with a twisting of the entire organ. In a case of this kind, which was carefully studied by L. Mazzotti,[1] the stomach was found occupying nearly the whole of the umbilical region. The organ was so constricted that the upper left portion was distended with gas and nearly vertical, while the horizontal right portion was collapsed and described almost an entire circle, the contracted part being the centre about which the rotation was effected. The organ being removed and distended the normal appearance was at once restored. A similar twisting

[1] Sewall, Med. and Phys. Journ., xxxi. 96.

[1] L'Union Médicale, 1875.

of the pyloric portion has been observed in cancer of the pylorus.

In diaphragmatic hernia the stomach and a portion of the transverse colon may be found lodged in the left side of the thorax.

The conspicuous relation existing between the greater curvature of the stomach and the omental cavities occasionally enters into a study of the morbid anatomy of the organ. Thus Brinton records a case of perforating ulcer of the stomach which opened into the cavity of the lesser omentum. Ponfick[1] describes in detail an aneurism the size of an almond situated on the right gastro-epiploic artery, which, bursting, escaped into the peritoneum, and the blood passed into the tissues along the base of the great omentum.

Perforating ulcer of the stomach and cancer of the stomach may communicate with the colon.—According to Pavy, ulceration of the stomach may prove fatal by opening into a branch of the splenic artery.[2]

The Small Intestine.

The Small Intestine (fig. 4, Plate C.; Plate LXIX.) is that portion of the alimentary canal between the stomach and the colon. It measures from twenty to twenty-five feet in length, and constitutes about two-thirds of the length of the digestive apparatus. This enormous bulk of tissue is entwined in coils held together by the mesentery, and occupies the umbilical region, although portions may be found in any of the regions of the abdomen.

The small intestine is larger above than below, a fact which has led some authorities to speak of it as funnel-shaped; the difference in the diameters scarcely warrants this comparison, however, though it is known that the measurements slightly diminish as the lower portion of the ileum is reached. The canal is divided into three portions, the duodenum, the jejunum, and the ileum.

The Duodenum.—The Duodenum (fig. 4, Plate CII.) is the smallest of these divisions, and is without mesenteric attachment. It extends from the pylorus at the right of the first lumbar to the left side of the third lumbar vertebra, and is fixed at its transverse portion by the superior mesenteric artery and by the pancreas. It is somewhat horse-shoe shaped, with its concavity directed to the left, and measures twelve inches in length. It is divided for purposes of description into three portions, the *ascending* (upper border of horseshoe), the *descending* (the curve of the horseshoe), and the *transverse* (the lower border of the horseshoe).

The *ascending*, or the shortest portion, starts from the pylorus of the stomach, and is directed upward, slightly backward to the right, where it lies in contact with the neck of the gall-bladder and the under surface of the liver. In front are the gastro-colic omentum and the abdominal parietes. Behind are the hepatic vessels and the gastro-hepatic omentum. The ascending portion ends abruptly in the *descending* portion which lies either upon or along the inner border of the kidney. It is embraced by the pancreas at its median anterior and posterior borders. The hepatic flexure of the colon is in front, while behind are situated the inferior vena cava and the common biliary duct.

The *terminal portion* is slightly the longest while the narrowest of the three. It passes across to the left side of the third lumbar vertebra to terminate at an angle in the jejunum. It is lodged deeply in the substance of the transverse mesocolon. Behind are the inferior vena cava, the thoracic duct, the aorta, the vertebral column, and the crura of the Diaphragm. Above lies the pancreas; in front, the stomach, from which it is separated by the peritoneum of the sac of the greater omentum.

The peritoneum forms a covering of the duodenum in the same manner as in the other divisions of the small intestine, except in its descending portion where the posterior surface is within the retro-peritoneal space.

The Jejunum and the Ileum.—The Jejunum and the Ileum may be considered together. They form a continuous tract measuring from fifteen to twenty feet in length, united posteriorly to the vertebral column by a long mesentery. The division is arbitrary. By general consent the first two-fifths have received the name of *jejunum*, and the remaining three-fifths the name of *ileum*. The walls of the former are somewhat thicker than those of the latter. The jejunum begins slightly to the left of the median line at the second lumbar vertebra; and the ileum terminates at the ileo-cæcal valve in the right iliac region. The general direction of the intestine is from left to right, and the mesentery of necessity pursues a similar direction, becoming broader as it descends from the second lumbar vertebra to the right sacro-iliac junction. When the jejunum and the ileum are empty they sag and in the main lie in the hypogastric region. In the emaciated subject they may be dragged down

[1] Virchow's Archiv, lxvii., 1876, 384 (fig.).

[2] Med. Times and Gaz., 1866, 35.

in great part into the pelvis. The coils of the intestine generally occupy the umbilical region, extending somewhat beyond it on either side, where they are ordinarily covered by the greater omentum.

The coats of the small intestine are four in number, the peritoneal, the longitudinal and circular muscular coats, the submucous coat, and the mucous membrane.

The *peritoneal* covering entirely incloses the canal save where it is joined by the mesentery. The *muscular coat* is better developed in the upper than in the lower part where the fibres are thinner and paler. The *longitudinal fibres*, weaker than the circular, lie immediately beneath the peritoneum, to which they are rather intimately attached. Though but moderately developed at any point, they are best seen on the anterior portion of the bowel. Below, this layer is continued over the ileo-cæcal valve upon the colon. The *circular layer* is composed of continuous fibres arranged about the entire circumference of the canal in a somewhat spiral manner. Unlike the longitudinal fibres they are involved in the formation of the ileo-cæcal valve. The *submucous layer* is better developed in the small intestine than in either the gastric or colic walls. It contains a few weak muscular fibres.

The *mucous coat* is probably the most complex structure of the kind in the body. Its essential features are as follows: To a mucous membrane presenting the general characters of all such surfaces are added (1), a series of remarkable folds; (2), a highly developed glandular system; (3), and an elaborate set of radicles of the lymphatic and portal systems projected into the interior of the bowel and constituting the *villi*.

Fig. 176.



From a vertical section through a fold of the mucous membrane of the jejunum of a dog. *c*, the mucosa, containing the crypts of Lieberkühn, and projecting as the villi; *m*, muscularis mucosæ; *s*, submucosa.

(1.) The *folds* are termed the *valvulæ conniventes*, or the valves of Kerkring. They are most numerous in the duodenum, and are continued as conspicuous features until the lower part of the ileum is reached, when they gradually disappear. They are composed entirely of duplications of the mucous membrane. They vary in shape from a crescentic fold to one possessing abrupt ends. Occasionally a fold extends entirely round the bowel, while others—and these are the more numerous—describe a smaller curve. They are about two-and-a-half inches long by one-third wide, but are somewhat larger in the duodenum where they overlap one on another. Not infrequently a fold divides again to unite after a short distance, inclosing an island-shaped space between. The folds present a peculiar arrangement as they reach a Peyerian patch. Here they are either arrested or pass partially over it in faint lines.

(2.) The *glands* are of three kinds: racemose, tubular, and closed.

The racemose glands are confined to the upper portion of the bowel; namely, to the duodenum and the beginning of the jejunum. In the duodenum, extending from just below the pylorus to near the descending portion, numbers of *duodenal glands* are seen which have received the name of glands of Brunner.

Fig. 177.



From a section through a part of a human Peyer's patch, showing the distribution of the lymphatic vessels in the mucosa and submucosa. *a*, villi, with central chyle vessel; *b*, Lieberkühn's crypts; *e*, region of muscularis mucosæ; *f*, lymph follicle; *g*, network of lymphatics around the lymph follicle; *l*, lymphatic network of the submucosa; *k*, an efferent lymphatic trunk.

The *tubular glands* are exceedingly abundant, being found everywhere throughout the small intestine.

The *closed glands* are rounded bodies lodged in the submucous coat, a small portion only appearing upon the free surface. They are very vascular, and have solid contents. They are appendages of the lymphatic system.

When a closed gland is isolated it is called *solitary;* when a number are collected in a small space they are called *agminated*, and the group itself is commonly spoken of as a *patch of Peyer* or *Peyerian patch*. The last-named group is found only upon the anterior surface of the ileum opposite the attachment of the mesentery.

(3.) The *villi* are distributed everywhere throughout the canal. As exceedingly minute processes they arise from the surface between the glands, commonly of a conical or clavate form, while in the duodenum they are somewhat lamelliform. They measure from one-fourth to one-third of a line in length. Each villus possesses a delicate lymphatic vessel, an artery, a vein and a nerve, as well as a delicate fasciculus of muscular fibres.

The *epithelium* of the small intestine is columnar.

Variations.—Billard[1] reports a case of a male child that died three days after birth, in which it was found that the lower third of the duodenum ended in a cul-de-sac, with fluid contents. The small intestine beyond the occlusion was so small that it barely admitted a female catheter. Förster[2] describes a somewhat similar specimen involving the jejunum.—For accounts of diverticuli of the small intestine, see p. 395.

Remarks and Relations.—The Duodenum entertains important relations with the stomach, liver, pancreas, transverse colon, jejunum, kidneys, supra-renal capsules, superior mesenteric artery, inferior vena cava, and aorta. Most of these relations are invariable, although those which pertain to the first portion of the duodenum are subject to greater changes than the others. It has been noticed, in describing the variations in the position of the pyloric extremity of the stomach, that under some conditions it appeared to glide almost insensibly into the first portion of the duodenum. In this condition both structures are empty and deep-seated, and easy regurgitation of ingesta and bile may occur from the duodenum into the stomach, while gall-stones may be lodged in the latter organ.[3]

When the stomach and duodenum are moderately distended, the first portion of the latter lies obliquely in front. It is near to, if not in direct contact with, the liver or gall-bladder. It is in this position that adhesions occur in so large a proportion of the cases of gall-stone migration, with subsequent escape of the calculus into the duodenum.—It is the right wall of this portion which is frequently selected for ulceration. Krause found that out of sixteen instances twelve were situated in the upper portion.

The vertical or middle portion of the duodenum lies between the vertebral column, the kidney, and the colon. It holds a fixed position with respect to the pancreas and pancreatic duct. When the ascending colon is distended, the vertical portion is thrown from the right to the left of the median line, moving altogether about two inches. It may lie directly to the right side of the first lumbar vertebra, or upon the twelfth dorsal vertebra, to the inner side of the inferior vena cava.

The relations between the first and the second portions of the duodenum and the termination of the ascending and beginning of the transverse colon are held by W. H. Flower[1] to have a significance referable to the primordial relations of the parts.

It is evident that the duodenum may communicate with the colon by a fistulous orifice either at the first or second of its divisions.

Sanderson[2] has recorded a case of the kind which occurred in a male, aged 30 years. Death ensued after an illness of two weeks. At the autopsy it was found that, at a distance of nine lines from the pylorus, the duodenum communicated by a wide aperture with a pouch about as large as a turkey's egg. By its posterior wall the pouch was very firmly adherent to the head of the pancreas, in front of which it lay. Below, the wall was inseparably blended with that of the transverse colon into which it opened by a valvular aperture large enough to allow of the passage of a swan's quill.

The lower portion of the duodenum is more fixed than any other portion of the intestine. This is chiefly owing to the relation entertained by it with the superior mesenteric artery, which passes over and in front of the duodenum. It is, moreover, fixed by the root of the mesocolon in front and by the pancreas above. In that rare diseased condition, aneurism of the superior mesenteric artery, the sac has been known to burst into the duodenum twenty-two months before death, thereby causing repeated attacks of hæmatemesis.[3] In two other cases, reported by J. A. Wilson,[4] pressure of the aneurismal sac had interfered with the flow of bile and induced jaundice.

The duodenum has been known to be ruptured by

[1] Traité des Malad. des Enfant. nouv.-nées, Paris, 1828, 348, fig.
[2] Missbildungen, Taf. xxiv. fig. 24.
[3] Jeaffreson, Br. Med. Journ., May 30, 1868.

[1] Med. Times and Gaz., March, 1872, 291.
[2] Tr. Path. Soc. Lond., 1865, xiv. 173.
[3] Gairdner, Clin. Med., 1862, 504.
[4] Medico-Chir. Trans., xxiv. 221.

violence, notwithstanding its sheltered position. Direct blows can scarcely reach the duodenum. The liver and transverse mesocolon protect its first portion as well probably as the transverse colon protects its transverse or terminal portion. Poland[1] cites three cases of rupture, in one of which there was a simple rent, one inch long, situated on the convex border of the first portion. In the second case the rent was likewise small, but situated on the descending portion; while in the third the gut was torn entirely across. Eccles[2] describes a case in which a child of twelve months suffered severance of the transverse from the vertical portion through a fall.

In cancer of the pancreas, the duodenum may become greatly contracted. The gut, according to Sir A. Cooper, may be forced forward by an engorged and distended thoracic duct.

The duodenum is often seen in emaciated subjects lying *above* the level of the transverse colon.

The regions of the abdomen normally occupied by the jejunum and ileum are the epigastric, umbilical, and portions of the other regions. The exact position varies exceedingly according to the condition of the stomach and of the colon. Thus, when the stomach is full, the intestines are depressed; when it is empty, they are elevated, and are often in contact with the Diaphragm in the left hypochondriac region. In distended states of the colon the intestines are excluded in great part from the lumbar, hypochondriac, and epigastric regions. When, in an obscure condition of the abdominal organs, it is desired to show from which portion of the cavity a tumor has projected, it is useful to remember that the tumor displaces the intestine in front of its line of advance. Thus, in enlarged conditions of the bladder, ovary, and uterus, the intestines are carried upward; in enlarged spleen downward and to the right. In peritoneal effusion they lie at the umbilicus in the recumbent, and in the epigastric region in the erect position. The last-mentioned fact is of value in distinguishing abdominal tumor from ascites.

"The small intestines when distended and occupying the pelvis have been known to so press upon the rectum as to prevent the lodgment of injections, and to cause the doubling of the long tube, which has led to the supposition that the obstruction was at the extremity of the colon, instead of in the ileum as appeared after death."[3]

[1] Guy's Hosp. Rep., 1858, iv. 123.

[2] Med. Times and Gaz., 1863, 497.

[3] Diseases of the Rectum. T. B. Curling, 4th ed., 177.

In a state of health the coils of intestine are closely applied to one another, so that it is possible for a portion of a coil to be opened and yet no feculent matter escape into the peritoneal cavity. It also follows that direct lesions of the mesentery are rare, and that the mesenteric side of the bowel is protected. However, a case is recorded by Birkett in which a rent one-and-a-half inch long, beginning in the mesentery, extended into the bowel. Bright[1] mentions a case in which convolutions of the small intestine, as well as the colon and omentum, lay in front of the liver and pressed it back.

The existence of fibrous adhesions uniting any portions of the coils of the intestine may seriously interfere with the ranges of variation in the relations of the bowel to the neighboring organs.

The anatomical considerations pertaining to intestinal obstruction naturally are of two kinds, viz., intrinsic and extrinsic. The intrinsic include *intussusception* and *torsion*. The extrinsic relate to peritoneal adhesions, or to *incarceration* of a portion of the intestine either within or without the abdomen.

Intussusception is caused by irregular contraction of the circular muscular coat of the intestine. The portion so constricted having a diameter much less than that directly beneath it, is urged by the general downward peristalsis of the bowel to enter the lower portion. It is thought by W. Brinton, who has made an exhaustive study of the subject,[2] that intussusception at this stage, as seen in the dead bodies of "young and well-nourished subjects, may occur in the irregular contractions of the last agony of death or be due to the rigor mortis of the dead intestine." There is no objection to the acceptance of the view that intussusception without obstruction may often take place during life, the symptoms attending such an occurrence being simply those of severe colic. When, however, the condition is maintained sufficiently long to be complicated with inflammatory effusion, obstruction rapidly supervenes. At the site of the invagination there are three thicknesses of the bowel. First, and most internal, is the constricted portion, which induces the invagination; second, the vagina-like portion embracing the above; and thirdly, the slightly dilated bowel below the intussuscepted point. The inflammatory effusion taking place between the serous surfaces of the first and second coverings will in a short time obliterate the narrow canal between them.

The arrangement of the mesentery determines

[1] Guy's Hosp. Rep., 1840, 317.

[2] Intestinal Obstruction.

from the very first a peculiarity of shape which all the succeeding phenomena tend to increase. The inverted middle layer or thickness receives, not merely the inner thickness but a kind of conical wedge of the mesentery common to both. The compression thus exercised on the large and numerous mesenteric vessels soon brings about a complete stagnation of their contents, followed by ecchymosis, or even by copious hemorrhage, in the adjacent uninjured mesentery, as well as by congestion and swelling of all the layers of the invaginated parts, and hemorrhage from the mucous membrane forming its innermost surface. Brinton[1] thus describes the appearance of this displacement: "The axis of the invaginated part diverges from that of the bowel containing it until, as the inversion proceeds, it forms a segment of a much smaller circle, and points by the terminal orifice of this segment to the mesenteric edge of the outer layer, with which the lowest part of the inversion is often in contact. The more distensible external or convex part of the middle layer is for the same reason thrown into folds somewhat resembling valvulæ conniventes."

The process is modified by the presence of the ileo-cæcal valve. A constriction just above the valve will, by its pressure downward, carry the valve, vermiform appendix, and cæcum downward within the colon. As a very rare occurrence the ileum passes into the cæcum through the ileo-cæcal valve.[2]

As a result of obstruction of the large intestine fecal matter may be forced up through the ileo-cæcal valve. In order that this should be possible, extreme distension of both cæcum and ileum becomes necessary, for in this way the efficiency of the valve is destroyed.

Torsion of the small intestine is due to the irregular action of both the longitudinal and the circular fibres. It is occasionally met with as a complication in hernia. M. W. Taylor[3] has recorded a rare instance of a torsion in the form of a knot on the lower part of the ileum occurring in a married woman forty years of age.

Extrinsic causes of obstruction are frequently found in adventitions bands of fibrous tissue extending between the loops of small intestine or from them to adjacent organs. J. H. Aldridge[4] has recorded a case in which the ileum above the ileo-cæcal valve had become firmly adherent to the posterior wall of the uterus.

[1] Loc. cit., p. 44, figs. [2] Ibid., 51.
[3] Edin. Med. Journ., Aug. 1871, 126 (fig.).
[4] Lancet, 1860, ii. 262.

Obstruction by incarceration is rarely of a character differing from inguinal or femoral hernia (q. v.), although it is necessary to bear in mind the possibility of an incarceration due to causes of another character. Of this condition a few examples will be given. A loop of small intestine may be caught, according to Delafield,[1] in the foramen of Winslow. Two feet of small intestine have been known to pass up into the left pleural cavity behind the *ligamentum arcuatum externum* in a child ten days old.[2] The escape of a knuckle of intestine through a hole in the omentum has occurred.

Again, diverticuli of intestine may act as factors in confining the bowel.

The existence of diverticuli in the form of long finger-like projections from the small intestine has long been known. They join the convex surface of the ileum about three feet above the ileo-cæcal valve, and vary in size from a small tit-like projection adherent to the mesentery to a process over three inches long. The walls possess abundant muscular tissue, and are furnished with villi. They have been known to become ulcerated. Their origin is believed to be due to the retention of the duct of communication between the vitelline sac and the intestine. In some cases diverticuli retain their primal relations to the umbilicus either by the full diameter, or by a fibrous cord. Hyrtl[3] found one with five branches in a hemicephalic monster. T. W. King[4] found a diverticulum united to the umbilicus in a child a year old.

Jas. H. Thompson[5] describes a case of a male aged twenty-five years in whom a coil of jejunum escaped through a space formed by adhesions between the end of a diverticulum and the mesentery, where it became strangulated. Parise[6] describes a similar case in which abdominal section was performed.

Rupture of the jejunum occurs so frequently at the upper portion of this bowel as to lead Poland[7] to the conclusion that the fixation of the transverse portion of the duodenum causes the strain of the contusion to be most severely felt at or near the end of the last-named viscus. Thus, out of nine cases collected by him, in which the exact locality of the rupture was stated, seven occurred near the duodenum, one at the junction of the middle and upper

[1] Pathological Anatomy.
[2] Boston Med. and Surg. Journ., 1838, 114.
[3] Typog. Anat., 684.
[4] Guy's Hosp. Rep., i., N. S., 1842, 470 (Figs.).
[5] N. Y. Med. Journ., xiv. 55.
[6] New York Med. Journ., xviii. 113.
[7] Poland, A., Guy's Hosp. Rep., 1858, series iii., iv. 123.

thirds of the jejunum, and one only in the lower part of the jejunum. In an example of this rupture reported by Mason,[1] occurring in a man aged twenty, who slipped and fell on the pavement, a small lacerated wound was found in the upper part of the jejunum, while in the last portion of the duodenum a clot of blood the size of a walnut was seen under the mucous membrane.

In intestinal hernia the patient may (from the knuckle acting as a fixed point) suffer rupture of the intestine from blows or falls. The rupture may occur at any point between the duodenal and hernial attachments. Poland cites three examples in which rupture of the intestine was coincident with hernia, and in all of these it was suspected that the hernial incarceration was a factor in the production of the lesion. The cases are almost necessarily fatal, and in the not unlikely event of herniotomy having been performed with the hope of relieving the condition, the real cause of mischief being obscured, medico-legal questions of great interest are apt to arise. Thus "a woman, affected with femoral hernia which occupied the labium, was struck by her husband on the abdomen, and died in twelve hours. The husband was convicted of having caused her death. The defence set up was, first, that the rupture occurred in the hernial sac, and that the rent in the bowel was caused by the efforts of the surgeon in reducing the hernia; and, secondly, supposing this not to have been the case, that the rupture was spontaneous and accidental from yielding of the diseased bowel. The arguments against these were, first, the pain came on immediately after the blow, second, the ruptured bowel was at a considerable distance from the sac, third, no inflammation or fecal matter was found in the sac, fourth, distinct external marks opposite to where the ruptured intestine lay, fifth, no appearance of ulceration of the mucous membrane."

In very severe contusions from blows received in front, it is possible, especially in thin persons, to make the vertebral column serve as the fixed point. Deuch[2] records a case of this kind, in which the ileum, as it lay across the vertebral column, just above the sacrum, suffered rupture from a kick; death ensued in twelve hours.

Fragments of bone when swallowed become less dangerous after they leave the stomach, the osseous material becoming dissolved or disintegrated by the gastric juice. The rarity of the occurrence of obstruction from such causes is remarkable, especially in the case of the lower animals, if we reflect upon the fact that dogs frequently swallow fragments of bone of various dimensions without any inconvenience. A case is mentioned of a female aged fifty-eight, who died of perforation of the ileum eight inches above the ileo-cæcal valve, caused by a fragment of beef-bone an inch and a quarter long, which had lodged crosswise near the constricted part of the bowel.[1]

In obstruction of the small intestine, bands, the result of some previous inflammation, play an important role. They either form the bonds of union of the intestine to the omentum, to the mesentery, or to an adjacent coil, or may be lodged in openings formed by rupture of the mesentery or of the omentum. It has been estimated that nearly one-third of all cases of obstruction are due to one or more of the above causes.[2]

Grawitz[3] has developed a theory of mechanical genesis of diverticuli colli (see p. 395, under mesenteric artery).

THE LARGE INTESTINE.

The Large Intestine (Plate LXIX.) extends from the termination of the ileum to the anus. It is divided into cæcum, colon, sigmoid flexure, and rectum.

The large intestine constitutes from one-fifth to one-fourth of the entire length of the alimentary canal. It is five feet long and one-and-a-half to two-and-a-half inches wide. Largest at its origin, it gradually diminishes in calibre until it reaches the sigmoid flexure, from which it again slightly widens at the beginning of the rectum.

Three longitudinal bands and a number of sacculations characterize the cæcum and the colon. The bands are confined to the fibrous layer, while the sacculations extend through all the coats; hence the former are seen only upon the periphery, but the latter are as well defined upon the inner as on the outer surface. After division of the bands the sacculations disappear.

The description of the colon embraces—

The Colon.
- Cæcum.
- Vermiform Appendix.
- Ascending Colon.
- Transverse Colon.
- Descending Colon.
- Sigmoid Flexure.

[1] Lancet, 1865, ii. 183.
[2] Vierteljahrsschrift für Gericht. Med., Bd. xvi. H. 2.

[1] Lancet, 1860, 611.
[2] W. W. Wagstaffe, St. Thomas's Hosp. Rep., 1873.
[3] Virchow's Arch., 1876, iv.

The Cæcum.—The Cæcum (fig. 1, Plate CII.) is placed between the ileum and the colon. It lies in the iliac fossa, and measures two-and-a-half inches in breadth. Behind and toward the median line of the body is the vermiform appendix. Though commonly in the same line as the ascending colon, the cæcum may form an obtuse angle with it. Its peritoneal covering is incomplete behind, thus bringing the structure in contact with the connective tissue of the iliac fossa. At times, however, it is completely enveloped by peritoneum, when a short meso-cæcum may be defined. The longitudinal coat of the ileum is continuous with that of the cæcum. The circular fibres and the mucous membrane are deflected as they pass from the ileum to the cæcum to form a pair of valve-like folds. This arrangement is termed the *ileo-cæcal valve* (valve of Bauhin). It is situated at the upper portion of the inner border of the cæcum, and is composed of two transverse folds, an upper and a lower, the latter being the larger of the two. The valves are covered with villi upon their upper surfaces, but none are found on the lower. Both folds are continuous above with the ileum, while the under surface of the upper fold is continuous with the colon, the under surface of the lower fold is continuous with the cæcum. The opening between these folds is of an elliptical shape. Its anterior end is turned forward and slightly to the left, while the posterior end is narrow and pointed.

Upon either side of the narrow ends of the opening is a ridge, or doubling, termed the frænum; this is shorter on the inner side.

The Vermiform Appendix.—The Vermiform Appendix is an elongated cylindrical structure continuous with the lower posterior and inner portion of the cæcum. It measures from three to five inches in length, and has the diameter of a goose-quill, but is often slightly wider at the mouth. Its walls are relatively thick as compared to those of the cæcum. The mucous lining is marked with numerous follicles and is smooth, except at its junction with the cæcum, where a well-defined fold exists. This fold is best seen in young persons from the third to the twelfth year, is inconstant in adults, and often disappears in old age.[1] Very rarely a spiral valve is found throughout the entire length of the appendix. The appendix is invested by peritoneum extending from the basal portion to the cæcum as a triangular fold, which has received the name of the *mesenteriolum* (Luschka). A portion of the ileo-cæcal fold reaches its base, beyond which is a pocket called the *ileo-cæcal recess*.

[1] Abhand. der Erlangen Phy. Med. Ges., ii. 7.

Relations.—Behind the appendix are the iliac fossa and the brim of the pelvis. In front are the inner border of the cæcum, and possibly the small intestine. To the inner side is the Psoas muscle, and to the outer side the cæcum.

As a rule, the appendix is bent once upon itself or twisted. It may be concealed beneath the cæcum, or may hang down in the cavity of the pelvis, where it has been known to effect adventitious adhesions with the pelvic organs, and even to perforate the bladder. Rarely it is lodged under the ascending colon, or deflected so as to be in contact with the abdominal wall. Cruveilhier records an instance in which it was contiguous with the liver. Other writers have mentioned the possibility of the appendix being caught in the mesentery,[1] or forming an ingredient of inguinal hernia.[2]

The vermiform appendix is of unknown function. It is found only in man, in the man-like apes, and in a marsupial animal—the wombat. It retains the embryonic characters of the large intestine, and is probably a rudiment of the enormous cæcum of quadrupeds of the rodent type.

Although thus structurally insignificant, its possible lesions may give rise to important clinical questions, and it is not infrequently a factor in retro-peritoneal abscess.[3]

The Colon.—The Colon intervenes between the cæcum and the sigmoid flexure. It is cylindrical in form, measures about two-and-a-half inches in diameter, and is marked in common with the cæcum with longitudinal bands and sacculations. It is divided into ascending, transverse, and descending portions.

The Ascending Colon passes nearly vertically upward along the right side of the abdomen to the under surface of the liver, whence it turns abruptly to the left to form the hepatic flexure, and passes into the transverse colon. It lies in front of the right kidney.

The Transverse Colon extends across between the ascending and descending portions beginning at the hepatic flexure and ending at the splenic. It is covered in front by the root of the great omentum. As a rule it lies across the upper part of the epigastric region, although it may be lower. The peritoneal covering is complete at the transverse colon, and forms the mesocolon, which extends from the

[1] N. Y. Med. Journ., iii. series, vol. i. 1856, 328.

[2] Med. Times and Gaz., 1868, 316.

[3] For a full discussion of this subject, see W. T. Bull, N. Y. Med. Journ., xviii. 240.

transverse portion backward to the vertebral column, and separates the stomach and the pancreas from the rest of the abdomen.

The Descending Colon begins at the splenic flexure and ends at the sigmoid flexure. It closely resembles the ascending portion, but is commonly more deeply seated, being concealed by coils of jejunum. According to Sappey, it is a little longer than the right, and is more closely related to the inner surface of the ribs.

The *structure* of the cæcum and the colon is simple. The longitudinal bands of muscle fibres are three in number, one on the inner, one upon the anterior, and the remaining one upon the posterior surface. The circular fibres are less conspicuous than in the small intestine, but present no peculiarity of interest.

The mucous membrane is thinner than in the small intestine, and is without villi. The closed glands are somewhat larger than in the small intestine, and not arranged in patches as in the ileum. They are most abundant in the vermiform appendix and the cæcum, gradually diminish in number thence within the ascending colon, and are commonly absent from the remainder of the bowel. The follicular glands, however, are everywhere numerous. Their open mouths present minute blackish points over the surface of the membrane. The epithelium is columnar.

The Sigmoid Flexure.—The Sigmoid Flexure is that portion of the large intestine which intervenes between the descending colon and the rectum. As the name implies, it is conspicuous for its **S**-like form, which causes it to extend forward and downward from the left iliac fossa. It is usually described as terminating at the sacro-iliac articulation, but in this respect it is exceedingly variable. The sigmoid flexure is held by a distinct peritoneal attachment to the iliac fossa. The sigmoid flexure is the most movable portion of the large intestine. Its minute structure recalls that of the colon.

In congenital absence of the rectum, the sigmoid flexure is so often observed to be thrown over to the right iliac fossa, that Huguier has proposed to form an artificial anus through the right iliac fossa rather than the left.

Remarks.—Under the practical remarks upon the colon may be considered (*a*) displacements; (*b*) torsion; (*c*) intussusception; (*d*) and the presence of diverticuli.

(*a*) *Displacements.*—The colon is of course most variable at the transverse portion. It normally extends across the abdomen opposite the twelfth dorsal vertebra, where it is in relation above with the liver and the gall-bladder, and lies just in advance of the first portion of the duodenum and the pyloric end of the stomach. It also occupies in part the left hypochondriac region in front of the spleen. The colon, when the stomach is empty, lies across the anterior surface of this organ. From these normal relations it may vary so as to lie transversely across any portion of the abdomen. It may, indeed, lie so low as to be in contact at one point with the cæcum. In diseased conditions these two portions of the colon may be thus united by adhesions. In a case recorded with details by Thurnam,[1] the transverse colon was found below the umbilicus and adherent to the cæcum. An abscess had formed about the point at which the transverse colon had become fixed to the integument and a fecal fistula established. The descending colon may cross the abdomen in front of the fourth lumbar vertebra, and form an ample convolution on the right side before terminating in the rectum—an important anatomical variation to remember in the operation of opening the colon in the left groin.

The descending colon, when inclined toward the median line, with the sigmoid flexure to the left, may be associated with misplacement of the left kidney.[2]

Either the ascending or descending colon may be pushed inward by an enlarged kidney.[3] Each may be fairly obliterated by the descent of an invagination at the ileo-cæcal valve.

With regard to the practical results following these displacements, the cæcum and beginning of the descending colon on the right side, and the sigmoid flexure or terminal part of the descending colon on the left, may be considered together. Both may be found among the contents of a hernial sac; both may be displaced to the median side; so that adhesions between the two are not among improbable lesions. Wilks has described an example of a cæcum which was found lying loose in the iliac fossa of the opposite side.[4]

The sigmoid flexure, however, from its peculiar position, and the relatively great length of its peritoneal attachments, having often a length of two-and-a-half inches, is the most liable to assume unusual positions. It may be thrown across to the right side of the abdomen, or, when loaded with feces, it may gravitate in the pelvis, when its lower portion becomes abruptly angulated with the rectum. Indeed, it would

[1] Trans. Path. Soc. Lond., 1848, 265.
[2] A. E. Durham, Guy's Hosp. Rep., 1860, iv. 413.
[3] C. A. Hare, Med. Times and Gaz., xiv. 1857.
[4] Med. Times and Gaz., 1862, 135.

appear likely that this is the physiological position of the flexure, since it retards the descent of the feculent matter. It is in this position that it is apt to effect adhesions with the pelvic viscera, and thus are explained those rare instances of fecal fistulæ opening into the bladder, the vagina, and even the vas deferens when the rectum is intact.

A case has been recorded by Handeside[1] in which during labor a rupture of the vaginal walls occurred. Eighteen inches of the sigmoid flexure protruded at the vulva.

According to J. Lewis Smith,[2] the *colon of the infant* is relatively longer and more movable than that of the adult. About one-fourth or one-third of the large intestine in children lies within the brim of the pelvis; and in speaking of the size and angulation of the sigmoid flexure in such subjects, this author advises against the insertion of a solid instrument further than one inch and a half from the anus. A. Jacobi[3] asserts that there is not *one only*, but several sigmoid flexures in children, owing to the manner in which this voluminous portion of the bowel is packed in the abdominal cavity.—John Abernethy narrates an instance in which the colon of an infant was found enormously enlarged, having a large flexure in the position of the transverse colon which reached the pelvis. The small intestine was but six feet in length.[4]

The *cæcum*, while covered entirely by peritoneum, as a rule, will occasionally have an open space behind in contact with the iliac fossa. But the size of this uncovered surface is not so large as it was supposed to be prior to the researches of Luschka.[5] By inserting the hand in either iliac fossa behind the peritoneum, the loose connective tissue can be readily pushed up toward the Quadratus Lumborum muscle. It is this locality which is so frequently the site of inflammatory processes, transmitted from the colon and pelvic organs,—the latter particularly in the female.

(*b*) *Torsion.*—The large intestine is more prone to twisting or irregular angulation of one portion of the bowel over another than is the small intestine. For reasons already given, the sigmoid flexure is especially liable to this lesion, one-half the recorded cases being in this portion of the canal. Next in order come the cæcum, then the ascending colon, and finally the transverse colon.[1] A good example of strangulation of intestine following rotation of the sigmoid flexure has been given by Jacob Bigelow.[2]

In the coats of the large intestine, as in the small intestine, the circular fibres pertain more especially to the mucous membrane, and the longitudinal to the peritoneal coat. H. B. Sands[3] records a case in which a rupture of the colon following extreme distension did not involve the mucous layer. Hyrtl[4] describes an extraordinary lesion inflicted by a suicide who, after opening his abdomen, cut off four-and-a-half inches of the transverse colon. At the cut end of the bowel, on the right side of the wound, he seized the mucous layer with its associated circular muscular fibres, and dragged five feet of it away from its normal connections, the peritoneal covering and the longitudinal muscular fibres alone remaining within the abdomen. On the left side the mucous membrane and circular muscular fibres protruded from the external wound twenty inches.

(*c*) *Intussusception.*—This is less frequently seen in the colon than in the small intestine. The mechanism, however, is the same. A case is described by A. Jacob.[5] of invagination of the descending colon in an infant, in which repeated hemorrhages took place in the transverse colon. Harrison[6] noticed an unusual form of this lesion, which consisted of the invagination of the transverse colon by the descending colon. The tumor created by the inclusion was about the size of an orange, freely movable, and situated between the umbilicus and the left ribs.

Obstruction of the colon may follow enormous deposition of fat beneath the peritoneum.[7]

(*d*) *The presence of Diverticuli.*—No true diverticuli occur in the large intestine; false examples, however, are occasionally met with. Sydney Jones[8] has recorded an interesting case of a male sixty-four years of age, who had suffered for years from a fecal fistula communicating with the bladder. At the autopsy it was found that the sigmoid flexure was contracted, and from among a number of false diverticuli of unequal length extending from this portion of the large intestine, one had effected entrance into

[1] Edinburgh Med. and Surg. Journ., 1873, xviii. 658.
[2] New York Med. Journ., x. 253.
[3] Sel. in Boston Med. and Surg. Journ. vi.
[4] Philosoph. Trans., 1809, xvii. 277 (figs.).
[5] Archiv für Path. Anat., xxi. 285.

[1] W. Brinton, Intestinal Obstruction, 1884, 84.
[2] Boston Med. and Surg. Journ., 1841, July 5.
[3] New York Med. Journ., xix. 622.
[4] Topograph. Anat., i. 686, where reference is made to Wochenblatt der Zeitschrift der ärtzlichen Gesellschaft in Wein, i., No. 8.
[5] New York Med. Journ., 1858, 355.
[6] Dublin Med. Press, 1845.
[7] H. Lenox Hodge, Trans. Path. Soc., Phila., 1877.
[8] Trans. Path. Soc. London, 1859, 132.

the bladder. Within the latter organ was found a phosphatic calculus the size of a horse-bean, having a nucleus of fecal matter.

Bloodvessels.—For the arteries of the small and the large intestine see the account of the branches of the abdominal aorta. The veins are tributary to the portal system of veins.

Nerves.—The nerves are derived from the pneumogastric nerve and from the superior mesenteric plexus of the sympathetic system.

Lymphatics.—The lymphatics join the mesenteric glands.

THE RECTUM.

The Rectum (fig. 4, Plate CI.; fig. 1, Plate C.) is that portion of the large intestine placed between the sigmoid flexure and the anus. As the name implies, it is straight, or at least relatively so; but when carefully examined the rectum is found to incline slightly from the left sacro-iliac symphysis to the median line of the sacrum opposite its third segment. Thence it descends, following the general curve of the sacrum. Within an inch of its termination the bowel is turned slightly backward to end at the anus. In addition to these deviations from a straight line, the rectum presents two lateral curves, one slight curve to the left side opposite the third segment of the sacrum, the other lower down, which inclines to the right.

For convenience of description, the rectum is divided into three portions, namely, the *upper*, the *middle*, and the *lower portion.*

The *upper* portion is one-half inch long, is entirely embraced by peritoneum, and connected to the sacrum by the meso-rectum, which carries the inferior mesenteric artery and vein, together with nerves and lymphatics. Behind are the sacro-iliac junction, the Pyriformis muscle, branches of the left internal iliac artery, and the origin of the sacral plexus.

The *middle* portion, which is three inches long, is in contact with the peritoneum only upon its anterior surface. Behind it are the lower portion of the sacrum and the corresponding part of the Pyriformis muscle. In continuing its curve forward it lies upon the coccyx and the muscular fibres arising therefrom. In front it is in relation with the base of the bladder, the vesiculæ seminales, the vasa deferentia, and the prostate gland. In the female it is in relation with the posterior surface of the bladder.

The *lower* portion, one inch long, is without peritoneum, and is surrounded by the fat of the ischio-rectal fossa. Its lower portion is embraced by the External Sphincter muscle. In front lie the membranous and bulbous portions of the urethra in the male, and of the vagina in the female. By the deflection of the third portion backward a triangular space is defined between the pudenda and the rectum.

Structure.—The minute anatomy of the rectum is much simpler than that of the small intestine, but is more complicated than that of the colon or of the sigmoid flexure. The canal presents an imperfect peritoneal layer already noticed, a muscular layer composed of longitudinal and circular fibres, a submucous layer, and the mucous membrane.

The muscular layer. The longitudinal layer of muscular fibres is paler than the circular, but better developed than in the colon. It is gradually lost toward the lower end of the rectum. A few fasciculi extend below the others and end in tendinous threads which, penetrating the fibres of the External Sphincter, are lost in the subcutaneous connective tissue. These bands correspond to the longitudinal folds of the rectum as seen upon the mucous membrane. Others of the fasciculi are inserted in the pelvic fascia, and a few upon the sacro-coccygeal ligament.—The circular fibres are better developed than the preceding. They end just above the anus in a well-defined edge termed the Internal Sphincter. As elsewhere through the alimentary canal, the circular layer is more intimately held to the mucous layer than to the longitudinal fibres.—The Tertiary Sphincter is a name occasionally given to the circular fibres at the beginning of the rectum. (See Remarks.)

The submucous connective tissue is abundant, and contains elastic tissue and lymphatic vessels. In it are imbedded the glands of the mucous layer.

The mucous membrane.—The mucous membrane bears in color and general appearance a resemblance to that of the œsophagus, and presents at its lower portion obscure reticulations recalling those seen on the mucous lining of the empty stomach. Near the anus it is provided with a number of folds, the most conspicuous of which are the longitudinal folds or columns of Morgagni which are seen at the lower part of the rectum. They correspond in position to well-marked fasciculi of the longitudinal muscular fibres, and in the contraction of the External Sphincter are prolonged to the verge of the anus. The lower ends are united by transverse folds which convert the intervals between the columns into pouches. At the junction of the upper and middle portions an oblique fold is seen, known as the valve of Houston.—The epithelium of the rectum is columnar, except at the anus, where it is squamous.

The glands of the rectum are few in number, and

of the racemose type. Immediately about the anus the glands are of the sebaceous variety.

Bloodvessels. The arteries of the rectum are the superior hæmorrhoidal, from the inferior mesenteric; the middle hæmorrhoidal, from the internal iliac or the internal pudic; and the inferior hæmorrhoidal, from the internal pudic. The first-mentioned is the most important of these vessels. It generally extends almost the entire length of the rectum; the middle hæmorrhoidal artery anastomoses with it. The inferior hæmorrhoidal is a small artery, and is for the most part distributed to the External Sphincter muscle and to the region of the anus. The veins join the internal hæmorrhoidal veins.

Nerves. The nerves are derived from the superior hæmorrhoidal plexus.

Lymphatics. The lymphatics join the lumbar glands.

Variations.—In some form of double monster with a single anus, each individual separately uses the orifice, *i. e.*, two sigmoid flexures join the rectum.

Remarks.—The three portions of the rectum above-mentioned serve as the best guides for the arrangement of its medical relations.

The first portion, by reason of its peritoneal investment, is in all its features an abdominal viscus. It is furnished with bloodvessels, nerves, and lymphatics from the same source as the colon; the colon presents no structural peculiarities not possessed by this portion of the rectum, except the longitudinal bands and sacculi. It is in this portion of the rectum that an occasional unusual development of the circular fibres retards the descent of the feces from the sigmoid flexure. In examples of loss of power of both the Internal and External Sphincters, incontinence of feces need not, therefore, occur, since periodic evacuations of the lower rectum may be entirely controlled. That such control, however, is not the rule is unfortunately too true, as many sufferers from impairment of the office of the lower sphincter can testify.—This portion of the rectum is very rarely the seat of organic stricture. According to H. Storer, ovarian cysts have been known to open into it.

In a state of health the rectum is empty, and its walls are in contact. The feculent matter lodged in the sigmoid flexure is in great part controlled, as already seen, by the circular fibres there situated, and its escape thence announces the desire for defecation. The fact, however, that in practice the rectum is so rarely found empty is proof of its frequent assumption of the office of a reservoir for feces. The habit of constipation, while demanding of the rectum a new function, lays the foundation of the great majority of its diseases.

The second (middle) portion of the rectum, since it is free from peritoneum at its lateral and posterior surfaces, is liable to compression from alterations in the loose connective tissue about it. Travers[1] describes a narrowing of this portion of the gut by dense fatty tissue, with subsequent ulceration into the peritoneal cavity.

The third portion is entirely free from peritoneum, and is in such intimate relations with the pelvic organs that its medical relations are of great importance.

The spaces behind and at the sides are occupied by delicate fat, which is continuous with the subcutaneous fat of the trunk and thighs. The yielding character of this tissue enables the rectum to be distended to a considerable distance without pressure upon any resisting point. In this way large quantities of fecal matter may be retained with comparative impunity. Prolonged irritation in the rectal walls will transmit to the connective tissue of the ischio-rectal fossa the exciting causes of inflammatory mischief, which, all things being equal, will exist in degrees of frequency proportionate to the violence of the initial trouble and the amount of extra-rectal fat. Persons who have large visceral organs, and whose abdominal walls and omentum are heavily loaded with fat, will often suffer from ischio-rectal abscess, due to portal congestion, and its resultant chronic rectal stasis. In the emaciated, an irritation is transmitted to the outside tissues from the partial or complete absorption of the fat. The physiological office accomplished by the latter tissue being in such patients absent, the distension of the bowel is accompanied with more or less friction, which not infrequently results in abscess. Thus, pus may form in the ischio-rectal fossa as the result of apparently opposite conditions, and in two classes of subjects whose physical appearances are strongly contrasted.

The ischio-rectal fossa is occasionally the seat of extensive traumatic injury Thus, a male aged forty years inadvertently sat down upon a conical oil-feeder for machines, the nozzle of which was five inches long; the ischio-rectal fossa was penetrated to a distance of four-and-a half inches, and, as a conse-

[1] Medico-Chir. Trans., xvii. 361.

quence, a large abscess was developed. The condition was successfully treated by dividing the External Sphincter.

In another instance, a penetrating wound of the rectum, produced by a stick forced up the rectum, caused gluteal abscess, from which escaped portions of the offending agent. In females, the lower portion of the rectum may be exposed by forcing the recto-vaginal septum backward and downward by digital pressure. In this way the anterior wall of the rectum can be temporarily forced through the anus, "like the finger of a glove," and thoroughly explored. In order that this procedure should be effective, it is best to rupture the External Sphincter by forcible dilatation with the fingers, a procedure originally proposed by Recamier and revived by W. H. Van Buren, of New York.[1]

The *terminal* portion (anal portion) of the rectum is in intimate relation with the cutaneous structures. It lies directly behind the prostate gland at first, but is soon deflected thence downward and backward, leaving between its anterior wall and the membranous portions of the urethra a triangular space.

The anus, being surrounded by the External Sphincter, is closely corrugated. It is slightly relaxed in the act of bearing down, so that the finger can be best inserted for examination of the rectum at such a time. Dr. Marion Sims[2] recommends that the patient be placed in the genu pectoral position, a posture certainly favoring the removal of all visceral pressure, and relaxing the External Sphincter. Dr. T. Gaillard Thomas[3] has suggested a similar procedure for making topical applications in rectal ulcers from chronic dysentery.

A healthy anus is well drawn up in the groove between the buttocks, and is, when the patient stands in the erect position, directed slightly backward. The finger being introduced meets with but moderate resistance. Turning the finger forward and backward, a capacious chamber is detected beyond the anterior wall of which lie the membranous portion of the urethra and the prostate gland.

An ischio-rectal abscess, however formed, is the precursor of a fistulous orifice either in the rectum or in the perineum. If the rectum be examined before the abscess opens, the bulging wall of the collection can easily be detected. This is especially noticeable in fat subjects, and it is with them that the collection is apt to open in the rectum, since this limiting wall is the least resisting. When the rectum is contracted and the surrounding parts defective in fat the integument is the least resisting, and the abscess-opening appears externally.

As an evidence that a knowledge of the anatomy of this region is essential to a true conception of its pathological processes the fact may be cited that anal fistule sometimes penetrates the fibres of the External Sphincter or Levator Ani muscles, or enters the rectum between this muscle and the Internal Sphincter.[1] The modern French writers assert that anal fistule always exists near the anus. It certainly may be expected to be found at or about the External Sphincter, although no conclusion with respect to this point can be considered as exact.

The anatomical features of each case of fistule must be separately considered. The so-called horse-shoe fistule, having a semicircular disposition around the bowel, but with a single opening into it, also the various forms of fistule confined to the coats of the rectum and particularly to the space between the circular and longitudinal muscular layers, are occasionally seen. They have been traced as far as the sigmoid flexure.

In rare instances the opening of communication between an ischio-rectal abscess and the bowel is so large that the feces have been forced through and have formed an ingredient of the ischio-rectal collection. Of this exceedingly dangerous form of fistule, L. A. Sayre[2] has described a good example in the person of an adult male, who, while suffering from a fistule on the left side, was subjected to the risks attending a fecal abscess occupying both ischio-rectal fossæ. The pressure to which the surrounding parts were subjected caused denudation of the tuberosities of the ischium and the left sacro-sciatic ligaments and coccyx, the latter in addition being detached from the sacrum.

The position of a fistulous orifice near the rectum should never be accepted as an evidence of rectal disease. It is certainly a probable inference that the rectum is involved if the opening is behind or at the sides of the anus, but an improbable inference if it is in front, since such openings in the latter locality are more apt to be a complication of peri-urethral or prostatic abscess, or even of pelvic inflammation.

The practical points worthy of attention in studying the *coats of the rectum* relate chiefly to the mucous membrane and the space between the circular and the longitudinal muscular coats.

[1] H. Storer, Amer. Journ. of Obstetrics, 1868, i. 369.

[2] Diseases of Rectum.

[3] N. Y. Med. Journ., 1875.

[1] Diseases of Rectum, Holmes's Syst. of Surg., 199, 202.

[2] New York Journ. Med., 1854, 178.

The mucous membrane of the first portion of the rectum does not differ from that of the sigmoid flexure. At the beginning of the middle portion, however, the variable oblique folds of Houston are seen. In the lower portion the folds are constant and longitudinal, and aid in limiting the rectal pouches. Below these is seen the flask-shaped end of the rectum, and at the terminus of the bowel are seen the corrugations of the anus.

The mucous lining of the rectum above the anus in the position of the longitudinal folds and the pouches is liable to a variety of local diseases. The normal amount of mucus lodged therein is capable of being enormously increased, as in chronic affections of the rectum. The pouches themselves are occasionally the site of cyst-like collections, and may also afford lodgment for seeds, fragments of bone, etc.

Stricture of the rectum is apt to be located either at the upper portion near the oblique fold of Houston or near the lower part at the longitudinal folds or pouches of Morgagni. The last-mentioned locality is almost universally the seat of the so-called venereal stricture so common in females. In twenty-one out of twenty-eight cases treated by T. Curling,[1] the stricture was within an inch to an inch-and-a-half of the anus.

Polypi also occupy almost exclusively the lower portion of the rectum. They are rarely found higher up than an inch or an inch-and-a-half above the anus.

Internal hæmorrhoids protrude in defecation and carry with them the mucous membrane.

Prolapsus of the rectum invariably takes place between the longitudinal and circular muscular fibres, which in the rectum preserve the same mutual relations as those already noticed in the colon, so that the longitudinal fibres remain in position, while the mucous membrane and the circular fibres descend.

Brodie mentions a case in which the intestine protruded at the anus, having effected entrance into the rectum by a slit on its anterior surface.

Knowledge of the position and course of the rectum is of importance in introducing a bougie or the nozzle of the enema syringe into the bowel. Cases have been recorded in which the intruding instrument was forced through the rectum into the peritoneal cavity or between the rectum and the sacrum. There is preserved in the museum of St. Bartholomew's Hospital, London, according to T. Bryant,[2] a specimen of the former lesion, in which the contents of the syringe had been introduced into the peritoneal cavity, where they were found after death.

A depression in the anal region and the position of the genitals far back would lead to the inference that the rectum was absent.[1]

Longitudinal defects of the rectum consist either in retention of the embryonic state of the uro-genital sinus, with the rectum opening into it, or else in the rectum being defective in whole or in part.

The rectum has been known to open into the bladder or vagina, conditions which make it possible for life to be sustained.

In much more frequent examples, it ceases to exist as a canal, and the space between its cul-de-sac and the perineum is occupied by fibrous tissue. The lower end of the bowel may be insensibly lost in the general tissue of the parts, or may be completely invested in peritoneum and possess a meso-rectum. When the rectum is obliterated at its first or second portions, no trace of the position of the anus is usually discoverable. But when it is continued near to the skin the anus is more or less well defined, and may be almost as in the normal state save that it is impervious. In such a condition the acts of crying, coughing, etc. will cause the anus to bulge and move slightly downward.

The large intestine may end at the middle of the transverse colon, as occurred in a reported case.[2] The anus, strange as it may appear, was patulous, admitting the finger one half an inch. The child lived nine days.

The skin about the anus is tightly adherent to the External Sphincter. In the relaxed condition of the parts due to protrusions, as in internal hæmorrhoids and prolapsus, the skin forms a small basal covering to the mass. When the tumor is restored to the bowel, the skin in question remains around the margins of the anus in loose pendulous folds. In operations on the anus these folds of skin should never be removed or included in a ligature, since it has been shown that the formation of a cicatrix therein is accompanied with excessive contraction, sufficient, if at all extensive, to lead to narrowing, and indeed to partial obstruction of the anal orifice.

[1] Diseases of Rectum, 4th ed., 122.

[2] Practice of Surgery, 345.

THE LIVER.

The Liver (figs. 2 and 3, Plate CII.; figs. 1, 4, and 5, Plate C.; fig. 1, Plate LXVIII.) is the organ for the secretion of bile. It is an appendage to the alimentary canal, yet it holds such peculiar relations both

[1] Curling, ibid. 201.

[2] Lancet, i. 1839, 794.

to the portal vein and to the vena cava, and by means of the latter empties its return-blood at a part of the inferior vena cava in such close proximity to the heart, that in one sense the liver is also an appendage to the bloodvessel system. Thus, it holds a double relation, one to alimentation, and the other to sanguinification. In the last-named group of functions may be included that of glycogenesis. Its color is of a dark reddish-brown.

The liver is situated in the right hypochondriac region, extending thence to the left. Above it lies the Diaphragm; below it lie the kidney, the hepatic flexure of the colon, part of the transverse colon, the pyloric portion of the stomach, and the larger part of the anterior surface of that organ. Behind it lie the inferior vena cava, the aorta, and the vertebral column; while behind, and to the right side, and in front it is embraced by the last six or seven ribs, with their intercostal cartilages.

In front the anterior edge can be felt through the abdominal walls in thin persons. The liver is chiefly fixed to the Diaphragm by intervening connective tissue; but its pendulous parts are held in position by folds of peritoneum termed ligaments, while the whole is buoyed up by the intestines.

The relations of the liver vary according to the position of the body and the state of the lungs. When the body is recumbent, the liver ascends from one to one-and-a-half inch; when the body is in the sitting posture, it descends.

In *inspiration*, the liver, according to Sibson, is not only lowered about half its height, but its summit is flattened—the entire organ gaining in width by being shortened from before backward. Instead of being protected by the ribs and cartilages, it is now thrown forward so as to be more prominent than the seventh or eighth costal cartilage, and the xiphoid cartilage, by from one-half of an inch to one inch. The præcordial space in expiration is somewhat resonant on percussion, but, by the movement of the liver just noted, the percussion-note over the præcordial space may become dull.

In *expiration* the liver ascends so as to be almost entirely concealed within that portion of the abdomen defined by the false ribs.

The position of the lower border of the liver will vary in different individuals, owing to normal variations in shape; it may lie two or three inches above the umbilicus; or a small portion of it only may be found to extend below the xiphoid cartilage. Accordingly, the lower edge of the liver is not an infallible guide to the size of the organ.

The liver is placed somewhat obliquely from before backward in such wise that the lower surface tends to look slightly forward as well as downward, a tendency which is increased by the shape of the stomach in repletion.

The shape of the liver is that of the upper segment of an ovoid cut obliquely lengthwise; the larger end lying to the right, from which position it narrows toward the left in all directions.

The liver measures ten to twelve inches from side to side (frontal section) by six to seven from before backward (sagittal section), and is three-and-a half inches deep. Its weight is from one and a half to four pounds. It may even reach a weight of seven and three-fourths pounds.[1]

The surfaces of the liver are two in number, a superior and an inferior; the borders are four in number: the anterior, the posterior, the external, and the internal.

The *superior surface* is smooth and convex, and answers to the general curve of the right side of the Diaphragm; beyond this point to the left it is flattened; to the right it is compressed by the false ribs, and behind it is continuous with the broad excavation for the vena cava.

The *inferior surface* is nearly flat, and presents a complicated relation of parts. To the left of the centre of the organ, extending across it from before backward, is the *longitudinal fissure*, the anterior

[1] D. Cuningham, Journ. of Anat. and Phys., 1879, 509.

EXPLANATION OF PLATE CII.

Fig. 1. A drawing of a dried preparation, which is designed to show the ileo-cæcal valve.

Fig. 2. The liver, seen from beneath.

Fig. 3. The liver, seen from above.

Fig. 4. A diagrammatic representation of the pancreas and duodenum in position to the vertebral columns, ribs, and the great vessels of the abdomen.

Fig. 1.

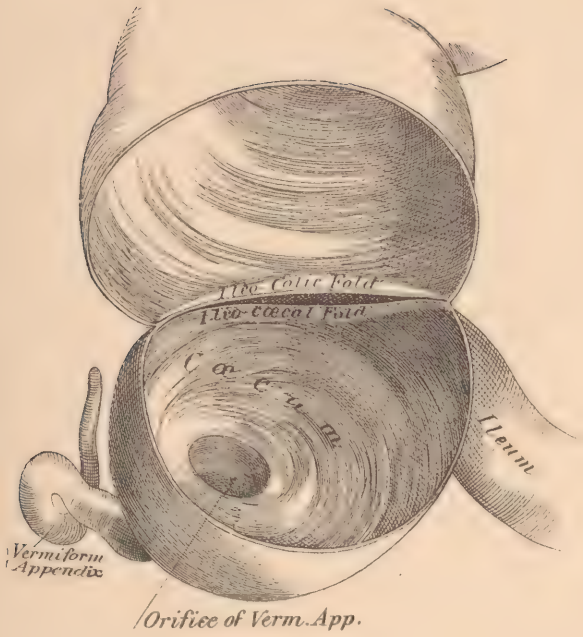


Fig. 2

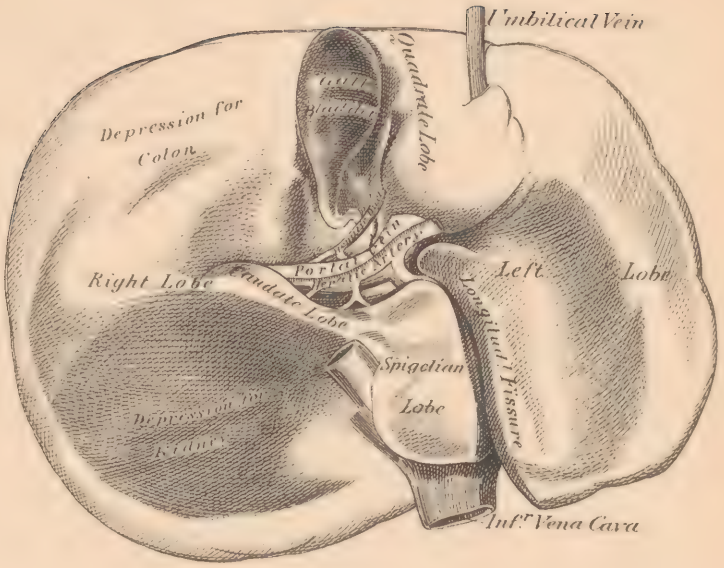


Fig. 3

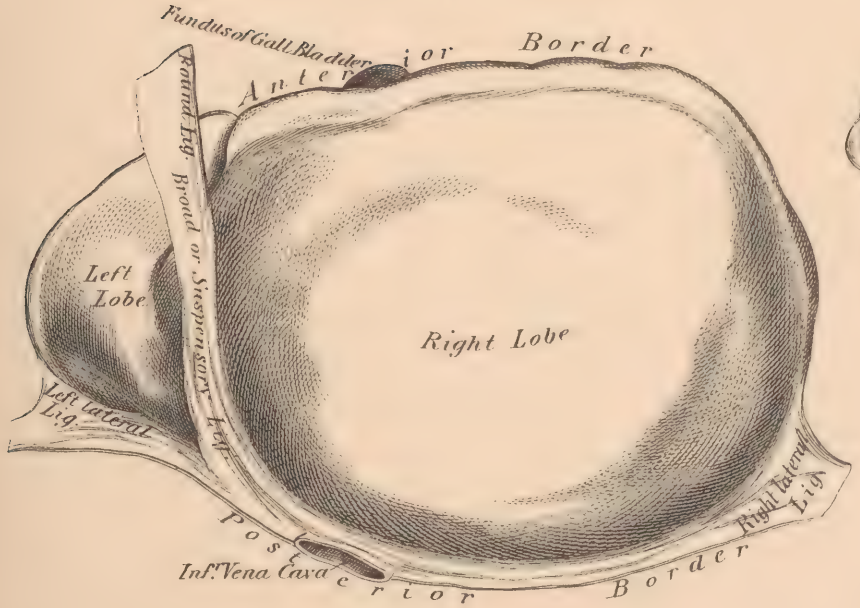
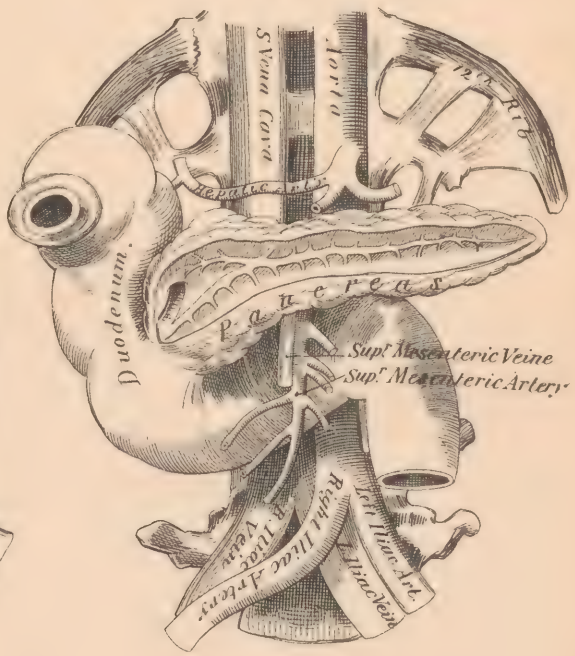


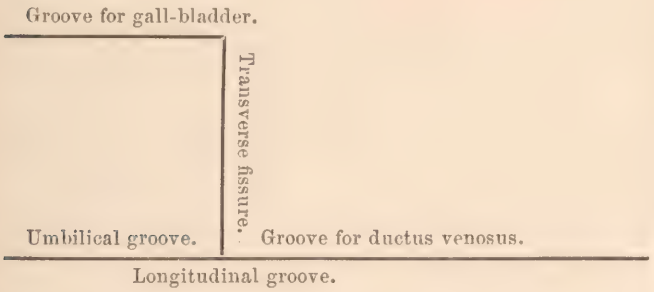
Fig. 4.



T. Sinclair & Son, Lith.

portion of which is occupied in the fœtus by the umbilical vein, and hence it is sometimes called the *umbilical groove*; across the posterior portion passes the obliterated ductus venosus, accommodated within the *groove for the ductus venosus*. Corresponding to the position of the gall-bladder is a groove known as the *groove for the gall-bladder*. Joining the extremities of the groove for the gall-bladder and the umbilical groove, is the *transverse fissure*. This lies in the middle of the under surface, measures twelve to fifteen lines in length, and accommodates the hepatic artery, portal vein, hepatic duct, and lymphatics. At the posterior border, and answering to a line continuous with the groove for the gall-bladder, is a small oblique *groove for the vena cava*.

The figure resulting from the union of the above-named fissures has been compared to the letter h, thus:—



In some specimens the groove for the vena cava is near the transverse fissure, when an H-like figure results. This is the normal arrangement according to Cruveilhier.

The under surface of the liver is marked by three shallow depressions for the right kidney, the colon, and the right supra-renal capsule.

When the liver is hardened in position it is seen that the figure above described is more or less conventional. The portion of the upper surface not covered with peritoneum, the Spigelian lobe, and the greater portion of the under surface of the left lobe look directly backward. These portions have been included by His in a posterior surface of the liver.

The Hepatic Notches.—The anterior border is marked by a notch for the umbilical vein. The posterior border is broadly notched or excavated by the vena cava and the vertebral column. Small bridges of hepatic tissue are apt to extend across the groove for the umbilical vein and the vena cava.

The Hepatic Lobes.—The under surface of the liver is divided into five lobes as usually described, viz., the right, left, quadrate, Spigelian, and caudate.

The umbilical fissure, and the groove for the dorsal vertebræ, separate the left lobe from the right. The umbilical fissure, the transverse fissure, and the groove for the gall-bladder separate the quadrate from the right lobe.

The groove for the remains of the ductus venosus, the groove for the vena cava, and the transverse fissure, separate the Spigelian lobe from the right lobe. Passing from the former to the latter is a small process of hepatic substance which has received the name of the caudate lobe.

The remainder of the under surface, *i. e.*, that portion to the right of the groove for the gall-bladder, and the upper surface from the interlobular notch to the right border, belongs to the *right lobe*.

Thus, of the five lobes, only the right and left are seen from above; and of the five the left is the most distinct; while the quadrate, Spigelian, and caudate are really differentiations from the under surface of the right lobe. These last-named lobes may be briefly defined as follows: the *quadrate* lies in front of the transverse fissure, between the umbilical fissure and the fissure of the gall-bladder. It presents a uniform flat surface. The *Spigelian* lobe lies behind the transverse fissure between the groove for the ductus venosus and the groove for the vena cava. It projects as a flattened semilunar process downward and backward, and is embraced by the lesser curvature of the stomach; its lower free surface corresponding to the upper border of the pancreas.—The Spigelian lobe is connected through a long isthmus or *caudate process* or lobe with the under surface of the right lobe. In front of the caudate process is the transverse fissure; behind it is the groove for the vena cava.

The Hepatic Ligaments.—The liver is not enveloped in the peritoneum, but has the posterior border free; this surface is in contact with the Diaphragm. The several folds of the peritoneum belonging to the liver are termed ligaments. These are as follows: the coronary, the lateral, the suspensory, and the round ligaments. To these may be added the gastro-hepatic omentum and two others, which are less defined, extending respectively from the liver to the kidney and to the colon.

The *coronary ligament* is the line of reflexion of the peritoneum from the Diaphragm to the upper surface of the liver on the one hand, and from the Diaphragm to the under surface on the other. Its main extent answers to the upper border of the posterior free surface of the liver.

The *lateral ligaments*, right and left, are triangular reflexions from the Diaphragm to the liver. The left is the longer and more slender, and lies in front of the œsophagus, by which it is slightly impressed. The right ligament lies in front of the vena cava, and extends from the middle of the right border to the Diaphragm.

The *suspensory ligament* is a falciform fold of the peritoneum, produced at a right angle from that membrane, where it joins the upper portion of the coronary ligament. It is broader in front than behind, and extends from the region of the umbilicus upward along the sheath of the Rectus muscle. It lies between the dorsum of the liver and the parietes of the abdomen and vault of the Diaphragm, at the line answering to the division of the liver into the right and left lobes.

The *round ligament* is the remains of the umbilical vein; it exists as a rounded cord which lies within the anterior border of the suspensory ligament, but leaves it to enter the umbilical groove of the longitudinal fissure, within which it lies.

The remaining folds of the peritoneum are best described in connection with the Peritoneum, *q. v.*

Structure.—The minute anatomy of the liver is exceedingly intricate. The following outline of its general plan is presented, both as to its bloodvessels and structure.

The liver, after eliminating certain products from the portal blood, returns it to the general circulation by the hepatic vein. This, the essential blood transit through the organ, is supplemented by the hepatic artery, which supplies the liver with the blood of nutrition. The terminal branches of the hepatic artery are received within a capillary network whose branches empty into the radicles of the hepatic vein; the blood, therefore, from both the portal vein and the hepatic artery empties by means of this common network into the hepatic vein. Between the cells held in the meshes of this network the bile-ducts begin.

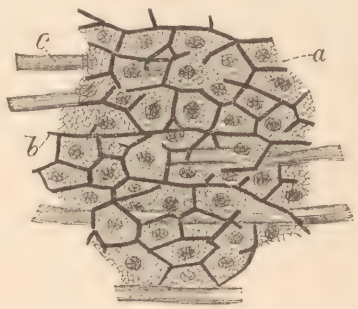
There are thus two distinct afferent trunks to the liver, the portal vein and the hepatic artery; and two distinct efferent trunks, the hepatic vein and hepatic duct.

At one point, *i. e.*, in the capillary network, an element of each of these structures is found, where the afferent trunk terminates, and the efferent trunk begins. The minute anatomy of the liver will now be examined in detail. Surrounding the portal vein, the hepatic artery, and the hepatic duct at the transverse fissure, is a connective-tissue membrane known as the capsule of Glisson. A layer of connective tissue can be demonstrated lying in the interval between the coronary ligaments, at the surface at which the liver is adherent to the Diaphragm, and between the folds of the lateral ligaments.

The general surface of the liver is smooth, differing in this respect from other glands; if, however, the surface be examined with care, it is seen to be composed of minute spheroidal or polyhedral bodies called the lobules or acini of the liver. Each lobule measures transversely from one-half of a line to one line in diameter.

The delicate spaces between the lobules are termed the interlobular spaces. The lobules, together with the bloodvessels and hepatic ducts, make up the substance of the liver

Fig. 178.



From a lobule of the liver of a rabbit, in which blood and bile-vessels had been injected. *a*, liver-cells; these are well shown as nucleated polygonal cells, each with a distinct reticulum; *b*, bile capillaries between the liver-cells; *c*, capillary bloodvessels.

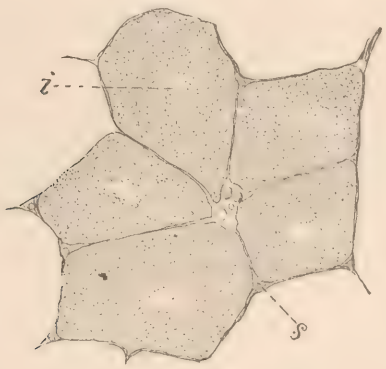
The walls of the bloodvessels within the liver are so thin that the liver is readily torn, the surface resulting being irregular and mottled. The centre of each lobule presents in a state of health a light yellow color, the border a dark brown shade; so that the general appearance of the cut surface of the organ is of a mottled shade of brown. The proper substance of the liver is composed of the *hepatic cells* (Fig. 176). These are of an irregular polyhedral form, and present a diameter of from $\frac{1}{1080}$ to $\frac{1}{349}$ of an inch. They are furnished with a nucleus, and contain a soft granular parenchyma and free oil globules. They are of a faint yellow color when isolated, but when massed yield the darkish-brown color characteristic of the liver.

In tracing the course of the vascular trunks and hepatic ducts within the liver, it is found that the portal vein, as it enters at the transverse fissure, abruptly divides into a number of vessels lying within the so-called portal tracts or canals, which each contain a portion of the trunks of the portal vein, the hepatic artery, and the bile-duct. These ascend nearly vertically through the substance of the liver, crossing the radicles of the hepatic vein at right angles. The branches of the latter vessel converge to the main trunk, which escapes at the posterior border of the liver to join the ascending vena cava. The arrangement of the two veins has been compared to two trees, whose trunks are at right angles, and whose terminal branches interlace. The hepatic artery and the hepatic duct accompany the portal vein through its general course, while the hepatic vein is without accompaniment.

The mechanism of the circulation of the liver can be best explained by directing attention to what takes place in the lobules. Each lobule is a miniature liver, having at its periphery between the lobules branches of the portal vein and

hepatic artery (interlobular branches), which freely intercommunicate and form through the lobule, between its periphery and centre, a capillary network. Directly at the centre the venules of this network (intralobular vessels) converge to form radicles of the hepatic vein.

Fig. 179.



From a section through the liver of pig. Five lobules are shown. They are well separated from one another by the interlobular tissue. *s*, interlobular connective tissue, containing the interlobular bloodvessels, *i. e.*, the branches of the hepatic artery and portal vein, and the interlobular bile-ducts; *i*, intralobular or central vein.

Within the same space in which this change of arterial to venous blood is being effected, the bile-ducts take their origin, and are directed towards the periphery of the lobule.

The Excretory Apparatus.

The Hepatic Excretory Apparatus consists of the
Hepatic Ducts.
Gall-bladder.
Cystic Duct.
Common Biliary Duct.

The Hepatic Ducts (bile-ducts), as they lie in the interlobular spaces, are well-defined canals having a fibrous coat with abundant elastic tissue, and a mucous membrane furnished with columnar epithelium. Everywhere, from this point downward, as they converge, the ducts are furnished with numerous glandular appendages in the form of lobated mucous follicles. These follicles in some of the larger ducts are so large and numerous as almost to conceal the main duct, and have been supposed by Henle to be the essential generators of the bile, while to the hepatic cells he would restrict the glycogenic function.

In following the majority of authors in believing the bile to be generated by the hepatic cells, it must be conceded that the bile as eliminated by the cells receives valuable accessions, probably of a viscid character, from the mucous glands, in the same manner that the seminal fluid receives additions from the glands appended to the urethra.

The Gall-Bladder is the reservoir for the bile. The organ lies in the groove of corresponding name situated between the quadrate and right lobes. Its shape is pyriform, its base being directed forward, its apex backward and slightly to the left. The fundus of the gall-bladder projects somewhat beyond the free border of the liver about opposite the tenth costal cartilage. Its apex, through the cystic duct, joins the hepatic duct at an acute angle to form the common biliary duct.

The gall-bladder measures from three to four inches in length, and one-and-a-half inch in breadth at the fundus. It has a capacity of from one-half to one-and-a-half fluidounce. In diseased conditions these measurements are materially modified. Murchison, for instance, cites an example of a gall-bladder seven inches in length.

The gall-bladder possesses three coats including the *peritoneum*, which, as a rule, envelops the under and lateral portions only. An example of complete peritoneal investment with defined meso-cystic fold is described by Hyrtl.[1] The upper surface lies in contact with the under surface of the liver, and is connected with it by a quantity of fine connective tissue. The remaining coats of the gall-bladder are the *fibrous* and *mucous* coats: the former of these presents no peculiarity; the latter is remarkable for the minute reticulation everywhere present upon its inner surface, and also for being stained by the bile a dark greenish-brown color. The epithelium is of the columnar variety. A few non-striated muscular fibres may be discerned in the walls of the gall-bladder. The *relations* of the organ are as follows: The fundus is in contact with the abdominal parietes near the tenth costal cartilage. The under surface lies upon the transverse colon, which fact can be often ascertained after death by this organ being discolored at the point of contact. Near its apex the under surface may touch the pylorus or first portion of the duodenum.

The Cystic Duct as it leaves the gall-bladder is bent twice abruptly upon itself like an italic *S*, but subsequently becomes straight. It is directed downward and inward. As above noted, it joins the hepatic duct at an acute angle. This duct is furnished with minute valves, varying from five to twelve in number, which are arranged in the form of

[1] Topog. Anat., i. 708.

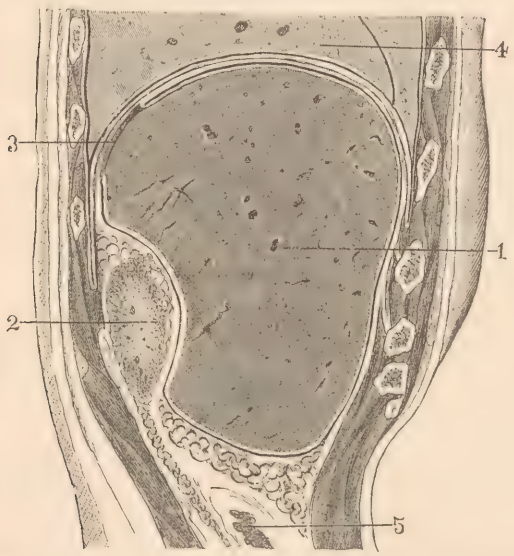
a spiral. According to Cruveilhier, they are irregular, alternate, and oblique.

The flow of bile from the gall-bladder outward is retarded in two ways: 1st. By the flexure at the apex which is due to fixation by the peritoneum, and which is readily effaced. 2d. By the valves within the duct, which are permanent.

The capillaries occupy the lobules, from the centres of which the venous blood escapes. The bile-ducts originate from above the hepatic cells, among the capillaries, and pass to the periphery. The manner of the elimination of the bile has been variously described. According to Leidy, whose researches were the first undertaken to prove the unity of construction of all gland tissue, the liver is a congeries of follicular glands which freely anastomose at their lower closed extremities, securing a reticular arrangement of tubes of basement membrane lined with hepatic cells. Beale has successfully demonstrated in the pig the existence of a system of interlobular tubes inclosing the hepatic cells. Chrzonszczewsky also has proved that there are canals among the hepatic cells.

The hepatic artery, in addition to supplying the lobules, yields branches to the portal canals or tracts, to the walls of the biliary ducts, and to the capsule of Glisson.

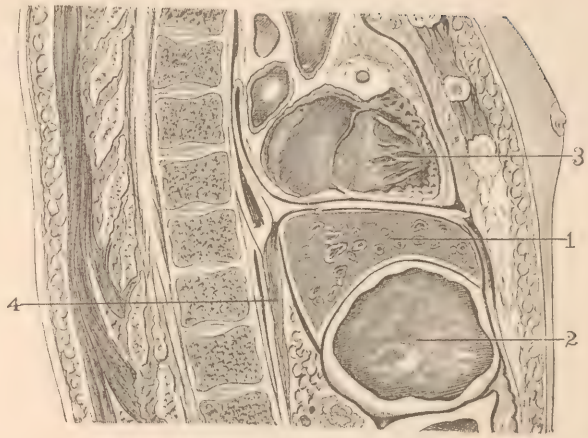
Fig. 180.



An antero-posterior (sagittal) section of the trunk in the mammary line. 1, liver; 2, right kidney; 3, the surface of the liver in contact with the Diaphragm; 4, the lower lobe of right lung; 5, ascending colon.

The Common Biliary Duct (ductus communis choledochus) is about three inches in length. It joins the duodenum at the middle of the vertical portion, about four inches from the stomach, penetrates the

Fig. 181.



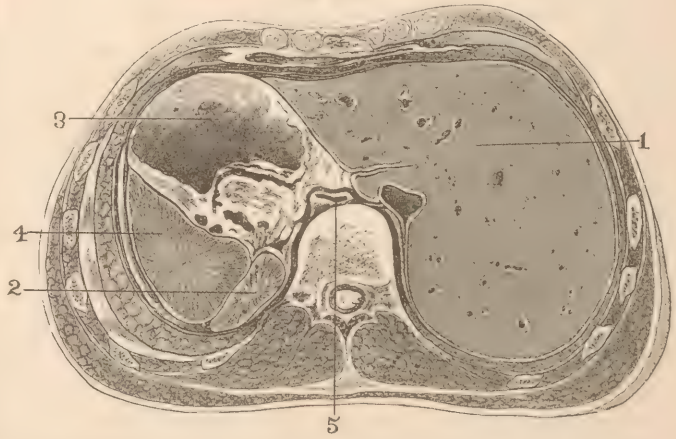
An antero-posterior (sagittal) section of the trunk in the median line. 1, the liver; 2, the stomach; 3, the heart; 4, one of the crura of the Diaphragm.

Fig. 182.



A transverse (frontal) section of the trunk. 1, the liver; 2, the stomach; 3, the lower lobe of left lung; 4, the heart; 5, the lower lobe of right lung; 6, the gall bladder; 7, the small intestine. The section of the largest tube to the left is the colon distended with flatus.

Fig. 183.

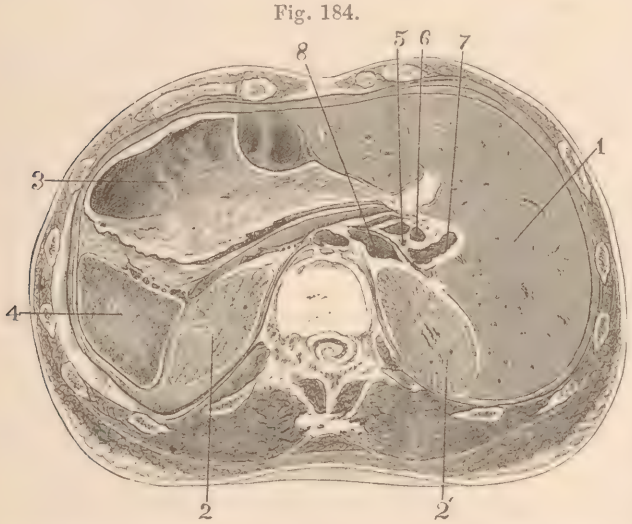


Horizontal section of the trunk at the level of the space between the ninth and tenth rib. 1, the liver; 2, the left kidney; 3, the stomach; 4, the spleen; 5, the œsophagus.

walls obliquely, and empties in the immediate neighborhood of the pancreatic duct. Its orifice is somewhat contracted just before entrance into the intestine.

Relations.—It lies in the gastro-hepatic omentum in front of the vena porta, below the hepatic artery; the right gastro-epiploica artery lies along its left side, together with lymphatic vessels and several lymphatic glands.

Fig. 184.



A horizontal section of the trunk at the level of the space between the twelfth dorsal and the first lumbar vertebra. 1, the liver; 2, the left kidney; 3, the stomach; 4, the spleen; 5, 6, section of the hepatic vessels; 7, the gall-bladder; 8, the inferior vena cava.

The following special study of the relations of the liver is based upon the investigations of Ludwig Mayer.[1]

Additional Relations.—The liver is for the most part embraced in the dome of the Diaphragm, having indirect relations only with the base of the bony thorax. Its relations, in consequence of its bulk and irregular shape, can be studied to the best advantage by sections made in the most suggestive positions, viz.:

An antero posterior section (sagittal section) through the mammary line.

An antero-posterior through the median line.

A (dextro-sinistral) transverse section (frontal section).

A horizontal section.

When an antero-posterior (sagittal) *section of the trunk is made through the mammary line, about two and three-quarters of an inch* (*seven centimeters*) *from the sternum and downward to the hip-joint* (Fig. 180), it is observed that the highest convexity of the liver is on a level with the fifth rib anteriorly and the eighth rib posteriorly, while it reaches three centimeters (one and three-sixteenths inches) above the last false rib. Its longitudinal diameter is nineteen centimeters (seven and one-half inches), and the transverse thirteen centimeters (five inches), as measured from the upper border of the right kidney. It lies in the vault of the Diaphragm, and reaches the posterior ends of the ribs. Anteriorly, the section reaches the abdominal wall and the four lower intercostal spaces and the corresponding ribs; posteriorly, it receives the right kidney(2) in a special depression; and interiorly lies a part of the omentum, beneath which is a portion of the ascending colon.(5) In young children the liver rises higher than it does in adults, and the lower margin descends below the costal arch in the right mammary line. In consequence of this, a small quantity of effused fluid in the right side of the pleural sac is more apt to escape notice, according to Eustace Smith,[1] the friction being often absent and the dulness attributed to the liver.

When an antero-posterior section is made in the median line (Fig. 181), the convex surface of the liver(1) is seen applied to the central tendon of the Diaphragm, and thus answering to that surface of the heart(3) which rests upon the Diaphragm, *i. e.*, to the left ventricle and the right auricle. The posterior border lies against the dorsal wall, or crura of the Diaphragm in the region of the ninth, tenth, and eleventh dorsal vertebræ. The concave under surface lies over the anterior superior surface of the stomach.(2)

Dr. A. von Brunn[2] has described as existing in the fœtus between the left lobe of the liver and the Diaphragm a bursa (*Bursa phrenico-hepaticus*) which appears to be connected with the original formation of the left lateral ligament.

When a transverse (*dextro-sinistral frontal*) *perpendicular section is made* (Fig. 182), the liver(1) is seen to lie at the plane of section opposite the seventh rib and to extend thence down to the twelfth. The section is of a triangular form, and occupies the angle defined by the thoracic wall, the heart, and the right lung. The left border goes slightly beyond the stomach, covering in the pyloric half of that organ, and the first portion of the duodenum. The outer right surface of the liver lies between the eighth and eleventh ribs and their intercostal muscles. If a needle is thrust between the seventh and eighth ribs, it will first traverse the pleural sac before entering the liver.

When a horizontal section is made between the ninth and tenth ribs (Fig. 183), the liver(1) is observed to be in close proximity to the right of the first lumbar vertebra.

Between the quadrate lobe and the right lobe as it lies near the kidney the gall-bladder is seen. In front of the gall-bladder lie the obliquely cut hepatic vessels and the portal vein. Between the liver and the inferior cava is a portion of the lesser omental sac. A part of the anterior half of the renal sulcus of the liver, since it is free from peritoneum, is applied directly to the capsule of the kidney, while its posterior part is separated from the kidney by the peritoneum. This relation is of importance in studying the evacuation of hepatic abscess and lesions of the bloodvessels.

When a horizontal section is made between the twelfth

[1] Die Wunden der Leber und Gallenblase, Munich, 1872.

[1] Clin. Studies of Diseases of Children, Lond., 1876, 102.

[2] Zeit. für Anat. und Entwickelungs geschichte, I. 3 and 4 Heft, Taf. vii.

dorsal and the first lumbar vertebra, the kidney is observed to lie to the median side of the liver as that organ is represented in the section. (Fig. 184.)

The relations of the liver are subject to manifold disturbances by the varying conditions of the abdominal organs and the *movements of respiration*. When the stomach is empty, the left edge of the liver inclines to the left side of the abdomen; when the stomach is distended, it pushes the liver somewhat upward. When the great and small intestines are empty, the liver descends in the abdomen; and when they are distended, it is pushed directly upward. In emphysema, and after tight-lacing, owing to the low position of the Diaphragm, the liver is usually low; and in phthisis, ascites, tympanites, abdominal tumor, and in the bed-ridden, in consequence of the high position of the Diaphragm, the liver is unusually high. Hence the position of the lower edge of the liver in the abdomen is not, in itself, a guide to the size of the liver.

During *inspiration*, or in emphysema, which may be roughly estimated as equivalent to an inspiratory displacement, the whole liver is lowered about one-and-a-half inch below the thoracic wall, and its convexity is flattened by the descent of the Diaphragm. An additional quantity of blood is thereby pressed into the right auricle at the very time that the lungs as well as the heart, owing to the expansion of the chest, are capable of holding more blood.

During *expiration*, on the other hand, the chest is contracted, and the right cavities being compressed, the blood accumulates in the liver and the veins of the neck. In expiration the thin edge of the liver usually appears for about a finger's width just below the xiphoid cartilage, and above the stomach and colon. In deep inspiration the liver descends toward the umbilicus, stretches across the epigastrium, between the left and right seventh and eighth costal cartilages, and forms an elastic rounded prominence, dull on percussion. As a general result, the liver, during a deep inspiration, is, according to Sibson,[1] compressed and shortened from above downward, widened from side to side, and lowered so that fully one-half of the organ is exposed below the ribs and cartilages, instead of being sheltered almost entirely within them.(1)

As a rare lesion Delafield[2] has found the transverse colon to be fixed above the liver so as to push it backward, downward, and to the right.

It is apparent, however, that most of these motions pertain to the right lobe. The left lobe is more fixed. A wound of the left lobe is liable to be complicated with severe hemorrhage into the abdominal cavity, owing to the proximity of the cœliac axis and its branches, whereas in the right lobe the hemorrhage is more apt to be external, and is not necessarily copious; though the wounding of the gall-bladder may lead to the accumulation of enormous quantities of bile-stained fluid in the abdominal cavity.

[1] Medical Anatomy. [2] Pathological Anatomy, 172.

The following paragraphs have been abridged from Murchison.

In percussion during life the upper margin of hepatic dulness may be said to be twofold, one boundary limiting the region where the organ is in close approximation to the walls of the chest, and where the dulness is absolute; the other corresponding to the extreme height of the liver, and including the space where it is overlapped by the thin layer of lung, and where the sound on percussion constitutes a transition from the hepatic dulness to the pulmonary resonance. It is the latter which is usually regarded as the true upper margin of the liver. There is a peculiarity in the upper margin of the hepatic dulness which is of some practical importance, namely, that it is not horizontal, but arched. Commencing posteriorly about the tenth or eleventh dorsal vertebra, it ascends gradually towards the axilla and the nipple, and then again descends slightly toward the median line in front.

In determining the upper margin of hepatic dulness, we must trust to percussion alone. In ordinary cases it is sufficient to note the upper limit in what is called the *right mammary line*, or a line descending perpendicularly from the right nipple. Here, in a healthy adult, the *true* upper margin of the liver is situated in the fifth intercostal space, or, in rare cases, behind the fifth rib or in the fourth intercostal space. In this line the liver is overlapped by lung to the extent of about one inch. But in all cases of suspected hepatic disease, the upper margin of hepatic dulness ought to be determined in its entire course. In the median line in front, it usually corresponds to the base of the ensiform cartilage, or rises slightly above this.

To the left of the median line it is difficult or impossible to define the upper limit of hepatic dulness from the lower boundary of the heart, the two being in apposition, but a line drawn from the upper margin of hepatic dulness in the median line to the apex of the heart will usually correspond to the line of separation. In the *right axillary line*, or a line falling perpendicularly from the centre of the axilla, the upper margin of hepatic dulness corresponds to the seventh intercostal space, or, more rarely, to the seventh rib. In the *right dorsal line*, or a line falling perpendicularly from the lower angle of the scapula (when the arm is dependent), it corresponds to the ninth intercostal space, or the ninth rib.

The lower margin of hepatic dulness may be determined by percussion, and often also by means of palpation. It is, however, as a rule, less easily defined than the upper margin, being often obscured by a distended condition of the stomach or intestines. Hence it is always most satisfactorily examined when the stomach is empty, and after the bowels have been freely moved. In the right mammary line, it usually corresponds with the margin of the costal arch, or is half an inch above or below this; in the right axillary line it corresponds to the tenth intercostal space; and in the right dorsal line to the twelfth rib, although here it is usually difficult to define it from the dulness of the kidney. In the epigastrium, the lower margin of the right and left lobes

usually descends two or three inches below the angle of junction of the last costal cartilage with the sternum.

The ordinary extent of hepatic dulness, in an adult of average size, is four inches in the right mammary line, four-and-a-half or five inches in the right axillary line, four inches in the right dorsal line, and three or four inches in the median line anteriorly.

The following table, from L. Mayer,[1] is designed to show the character of the lesions of internal organs accompanying gunshot and other wounds in the neighborhood of the liver. It is thought that from it some approximation of the degree and locality of an injury may be secured, the point of entrance, exit, or lodgment of a projectile being previously known. It is evident, from the conditions determining the relations and size of the liver, that nothing but an approximation can in *all* cases be premised. The table is based upon an elaborate series of experiments on the effects of gunshot wounds upon the cadaver.

Entrance of projectile in front and to the right side.	*Viscera wounded.*
1. Entrance beneath right nipple; exit inferior end of 12th rib.	Lung and liver.
2. Entrance at the 7th rib near outer end of the costal cartilage; exit a hand's-breadth to the right of the vertebral column.	Liver.
3. Entrance between the 7th and 8th ribs; exit behind corresponding to 11th rib.	Liver.
4. Entrance between the 8th and 9th ribs 8 inches from the median line; exit between 11th and 12th left ribs ½ inch from their articulations.	Liver and left kidney.
5. Entrance between the 8th and 9th ribs forward and somewhat laterally; exit on level with 11th right rib 4 inches from the vertebral column.	Liver and right lung.
6. Entrance through the 9th rib backward on level with 1st lumbar vertebra.	Liver and right kidney.
7. Entrance neighborhood of 9th and 10th ribs 3½ inches from ensiform cartilage; exit between 7th and 8th ribs near vertebral column.	Liver.
8. Entrance between 10th and 11th ribs; exit behind, 1½ inch from vertebral column.	Liver and colon.

Entrance of projectile in front and to the left side.	*Viscera wounded.*
1. Entrance above and 2 inches to left of umbilicus.	Left and right lobes of liver. Ball found lying in duodenum.
2. Entrance near præcordium.	Inferior border of right lung, Diaphragm, left lobe of liver, anterior and posterior wall of stomach.
3. Entrance at epigastric region to the left side of the ensiform cartilage.	Liver.
4. Entrance behind the 7th and 8th ribs.	Lung, Diaphragm, spleen, and right lobe of liver.
5. Entrance behind 5th and 6th ribs of left side toward right side.	Liver.

Entrance of projectile to right hypochondriac, epigastric, and umbilical regions.	*Viscera wounded.*
1. Entrance 2 or 3 fingers'-breadth beneath the last right costal cartilage; exit backward between 10th and 11th ribs of right side.	Upper portion of liver.
2. In right hypochondrium.	Liver and Diaphragm.
3. Entrance anterior and upper portions of the right hypochondrium; exit opposite.	Liver.
4. Entrance at the right hypochondrium and the borders of the false ribs.	Liver.
5. Entrance at right hypochond. 5 in. from median line; exit over right ileum 2 inches from median line.	Liver.
6. Entrance in right hypochondrium; exit near inferior angle of scapula	Liver.
7. Entrance under ensiform cartilage; exit to the left between 2d and 3d false ribs, near the vertebral column.	Liver, pancreas, spleen, Diaphragm, right ventricle, and vertebral column.

Entrance of projectile from behind.	*Viscera wounded.*
1. Entrance on the level of the 8th rib a hand's-breadth from the vertebral column; exit in front of mammary line, fracturing 7th right rib.	Liver.
2. Entrance between 8th and 9th ribs; exit between the 7th and 8th ribs 4½ inches from the sternum.	Liver.
3. Entrance between 8th and 9th right ribs 2½ inches from vertebral column; exit between the 7th and 8th right ribs 4½ inches from the sternum.	Liver.

[1] Loc. cit., p. 70 (see p. 365).

Entrance of projectile from behind.	*Viscera wounded.*
4. Entrance between the 9th and 10th right ribs; exit to right of ensiform cartilage.	Prolapsus of lung through wound; wound of liver.
5. Entrance 2 inches from vertebral column on right side on level with 12th dorsal vertebra; exit a short distance from the ensiform cartilage on the right at the lower border of the liver.	Right lobe of the liver.
6. Entrance 4 inches above crest of the ilium 6 inches from the vertebral column.	Liver.
7. Near lumbar vertebræ through the last inferior right rib.	Right kidney; ball lodged $\frac{1}{2}$ inch in liver.

Penetrating wounds.	*Viscera wounded.*
1. Bayonet wound under left false ribs perpendicular to gladiolus, 2 inches above hip; 1 in. wide; course obliquely upward and inward.	Colon, stomach, left lobe of liver, Diaphragm, right ventricle, and right lung.
2. 1 inch broad on left side of breast.	Left lobe of liver, and outer layer of stomach.
3. Knife-wound 1 inch long, $\frac{1}{2}$ wide, on left side of thorax.	Diaphragm, liver.
4. Sabre wound of left side 5 inches over the crest of ilium to the middle of the 3d false rib.	Right ventricle, Diaphragm, left lobe of liver, stomach, spleen, descending colon.
5. Wound between 7th and 8th ribs on right side obliquely downwards.	Diaphragm and liver.
6. Sword-wound on right side between 8th and 9th ribs.	Right lobe of liver, right lobe of lung, right supra-renal capsule and Diaphragm; liver.
7. Fencing-foil wound between 8th and 9th ribs, 3 to 4 lines wide.	Diaphragm and liver.
8. Transverse wound of right side between 9th and 10th ribs.	Liver and Diaphragm.
9. Bayonet wound between 10th and 11th ribs, right side.	Liver.
10. Sword-wound on antero-lateral surface of right hypochondrium two fingers'-breadth under false ribs.	Right lobe of the liver.
11. Knife wound of right side of abdomen, 3 inches long, $\frac{3}{4}$ in. wide	Liver.
12. 4 in. deep wound in the præcordium obliquely upwards.	Concave surface left lobe of liver.

Variations.—The left lobe of the liver may extend entirely across the abdomen (Gruber).

Remarks.—The clinical applications of a knowledge of the anatomy of the liver are both numerous and important. They relate to the parenchyma and to the relations of the viscus.

The *parenchyma of the liver* in its manner of response to injury bears a close resemblance to that of the spleen.

The capsule may be intact in cases where the parenchyma has been the seat of extensive laceration.[1] The liver is frequently contused in falls from lofty places, and as the result of such circumstances has been found torn in half without any lesion of the skin over the organ.[2]

The clinical study of the *relations of the liver* can be embraced under the following heads: (*a*) to the Diaphragm; (*b*) to the peritoneum; (*c*) to the stomach, colon, and duodenum; (*d*) to the pericardium and the heart; (*e*) to the bloodvessels; (*f*) to the biliary ducts and to the gall-bladder; (*g*) to the structures about the left lobe.

(*a*) Hydatids or abscess of the liver may discharge through the Diaphragm into the right pleural cavity. Out of 189 cases of hepatic hydatid, 81 had so discharged (Frerichs), and out of 300 cases of hepatic abscess reported by Waring 42 opened into the thoracic cavity.[3]

When adhesions have involved the base of the lung the hydatid mass or the pus may be discharged by the bronchial tubes. Fatal pleurisy may result from the upward pressure of a hydatid tumor of the liver without perforation of the Diaphragm.[4]

The connective-tissue interval between the liver and the Diaphragm may be the seat of an abscess, as recorded by Bright.[5]

From its relation to the abdominal parietes the liver—being forced in inspiration from above downward—is liable to compression, which indirectly aids in hepatic circulation. More particularly such compression will assist in forcing blood from the capillaries into the radicals of the hepatic vein. J. Hilton[6] infers that the hepatic congestion which is apt to follow enforced rest in bed in individuals who have previously led active lives is due to the sudden withdrawal of this abdominal and diaphragmatic pressure.

[1] Pollock, Holmes's Sys. of Surg., iii. 416.
[2] L. S. Smith, Lancet, 1861, 208.
[3] Murchison, 175.
[4] Ibid. 63.
[5] Clinical Memoirs on Abdominal Tumors, Syd. Soc. ed., 257.
[6] On Rest and Pain, 231, 1877.

(*b*) The *peritoneum* is frequently involved in hepatic disease. Hydatid tumors often terminate fatally by rupture into the abdominal cavity. It is estimated by Waring that out of every three hundred cases of hepatic abscess fifteen will involve the peritoneum.

R. S. Orr,[1] in a case of hepatic abscess, found the pus in the gastro-hepatic omentum and about the duodenum and the pancreas.

(*c*) The *stomach*, the *colon*, and the *duodenum* are, from their extensive contact with the under surface of the liver, presumably liable to inflammatory involvement and afford probable points of outlet of fluid. Davaine has collected eleven cases, of which six were fatal, where hydatid tumor of the liver appeared to open into the stomach; and fifteen, of which only one was fatal, where there was reason to believe that it had opened into the intestine.[2]

The small intestine rarely enters into relationship with the liver. Bright[3] found not only the colon and omentum but the small intestine lying in front of the liver, at the same time being pressed against it so as to make deep impressions upon its anterior surface. In such a case it can be seen how pus might readily pass from the liver into the small intestine and colon, or how readily the contiguous structures could be wounded by a single missile. W. Warren[4] records a case of a needle-perforation of the walls of the stomach involving the liver in a child of eleven years. Intestinal hemorrhage and peritoneal adhesions between the organs ensued.

(*d*) The left lobe of the liver is less liable to interference than the other portions of the organ—a circumstance due to the diminished mobility of this lobe, and to the fact that it is in great measure removed from the causes of abscess and hydatid tumor. The most important clinical relation of the left lobe is with the pericardium.

The relations of the left lobe.—The left lobe of the liver enters into relations which in a clinical sense can be considered separately from those of the other lobes. The two divisions of the liver are drained by distinct sets of lymphatics. Malignant tumors may be confined to the left lobe, which, under these circumstances, may be confounded with enlarged conditions of the spleen.

Murchison[5] refers to three cases only in which the pericardium was penetrated by an hepatic hydatid. All proved fatal either instantaneously by embarrassment of the heart's action, or within a few hours by acute pericarditis. Mr. Bentley[1] narrates a case of hepatic abscess opening into the pericardium. A male, 29 years of age, was seized suddenly with pain to the right of the xiphoid cartilage, accompanied with dyspnœa and followed by cough and expectoration. Eight months afterward the patient was attacked with nausea, and pain in the præcordium. Death took place a few hours thereafter. At the autopsy it was found that the left lobe of the liver was occupied almost entirely by an abscess. The liver was greatly enlarged and adherent to the Diaphragm. The abscess communicated with the pericardium by a nipple-shaped opening.

The relations of the liver with the foramen of Winslow.—In examination of the abdomen after death in obscure morbid conditions, it is well to observe the appearance of the foramen of Winslow. Serving as it does to connect the greater with the lesser peritoneal chamber, this opening has been known to be a thoroughfare for fluids and growths of different kinds, by which they can pass from one peritoneal subchamber to the other. Thus, an hydatid cyst which originates in the liver has been detected projecting through the enlarged foramen.

The parietal relations of the liver.—The parietal relations of the liver are not important from an anatomical point of view, since any protrusion from the liver in this direction is at once recognizable by palpation. It is, all things considered, a rare circumstance for collections of fluid or tumors to project toward the periphery, because of the firm resistance interposed by the Diaphragm, the ribs, and the Intercostal muscles.

(*e*) Instances of hepatic abscess opening into the inferior vena cava, of involvement of the portal vein (Hyrtl) and of the hepatic vein from similar causes (Davaine), have been recorded.—The remains of the umbilical vein, passing from the liver to the umbilicus, have served to guide the flow of pus from an hepatic abscess to the umbilicus. If, therefore, pus be induced by pressure to flow from a patulous umbilicus, and a probe be introduced into a sinus which extends upward toward the liver, it is probable that there is a collection of pus in or about that organ.

In examination of the liver of emaciated subjects, the viscus is sometimes found lying against the inferior vena cava and retarding, if not preventing, the ascent of injecting fluid along this vessel. It is not known that any similar causes operate in exciting

[1] Glas. Med. Journ., 1862, x. 284.
[2] See Murchison, Diseases of the Liver, 66.
[3] Guy's Hosp. Rep., 1840, 37.
[4] Lancet, ii., 1868.
[5] Loc. cit., 64.

[1] Tr. Path. Soc. Lond., ii. 70.

mechanical congestions of the cava during life.—In cirrhosis of the liver the portal and hepatic veins are both constricted.

(*f*) *The biliary ducts and the gall-bladder.*—The exposed position of the excretory apparatus of the liver from the transverse fissure to the duodenum renders it peculiarly liable to pressure from adjacent parts; and when it is remembered that none of the several structures in this apparatus present any resistance to such outward pressure, it is not remarkable that mechanical obstruction to the flow of bile is a frequent clinical phenomenon. It should be recalled that the common biliary duct is most liable to be subjected to such pressure, since it lies exposed upon the anterior surface of the gastro-hepatic omentum in front of the portal vein and under the hepatic artery. These parts are easily seen in dissection by elevating the liver and depressing the stomach and the transverse colon. When the organs are preserved *in situ*, the student must think of them as *relaxed*. In this condition an unusual degree of pressure maintained for some time will be required to induce mechanical obstruction. But, should co-related conditions be such that the common duct is made *tense* in the gastro-hepatic omentum, slight degrees of pressure, particularly if they are exerted from *in front*, will suffice to occlude the common biliary duct.

Sibson states that, in estimating the descent and advance of the liver, the spleen, and the pancreas, the ascent and advance of the lower sternal ribs and cartilages must be taken into account. While the latter ascend and advance about an inch, the former descend and advance nearly two inches. In relation to the ribs and cartilages, the liver moves downward about three inches, but forward scarcely one inch, since their elevation adds to the depression and their expansion lessens the protrusion of the liver. The inspiratory lowering of the liver is notably greater than that of the stomach and the spleen, owing to the great height to which the organ first named rises in the right side of the dome of the Diaphragm. It is evident that such descent will relax the common biliary duct, since the movements of the pancreas must be less than those of the liver, if, indeed, the former structure, held as it is to the fixed middle portion of the duodenum, can be said to have any true downward movement. It will follow that in expiration, when the liver ascends, the common duct will be tense. It will also follow, all things being equal, that obstruction from outward pressure will be more apt to occur as a complication in conditions in which the liver is high up, as in the expiratory position, than in those conditions in which it is low down, as in the inspiratory position.

It is a reasonable inference that in spontaneous rupture of the common duct three inches from the duodenum, such as happened in a case recorded by McSwiney,[1] the lesion occurred in deep expiration or with the liver in the position corresponding thereto. In Clark's case[2] of traumatic rupture of the duct, the force exciting the injury was severe, viz., a crushing of the body between two wagons, as the duct, even when relaxed, will yield to extraordinary pressure. The liver suffered but slight laceration, which was confined to the under surface of the organ. The hepatic duct (*i. e.* the duct above the common biliary duct) may be ruptured from injury. Death ensues from escape of bile into the peritoneal cavity.—In a case reported by T. M. Drysdale,[3] traumatic rupture of the biliary duct was followed by enormous distension of the abdomen with a bile-stained serum.

Enlargements of existing organs, or new growths, placed toward the median side of the liver, will by their advancement toward the right side push the liver in front of them and to the right. This will tend, conceding the fixed position of the middle portion of the duodenum, to be of constant value in producing tension of the common duct. On the other hand, protrusions of any kind behind the liver, by throwing it inward, will relax the duct.

A knuckle of large intestine may intrude itself between the Diaphragm and the liver.

Since the under surface of the liver is in contact with the pyloric end of the stomach, the transverse colon, and the first portion of the duodenum, the more obvious sources of visceral pressure against the liver will arise from them. The colon is especially apt to press against the common duct from two causes: first, from the lodgment of scybalous masses in the canal in persons of a constipated habit; and, secondly, from the enormous gaseous distension to which this portion of the large intestine is liable.—Pressure exerted from the stomach is frequently associated with cancer of the pylorus.

Among the sources of pressure which are capable of occluding the common duct, and which yet might not attract the attention of the student in examining the normal relations of the duct, are the following:—

Causes operating at the hepatic end of the duct.—Conspicuous among these are lymphatic glands in the

[1] Dublin Journal of Medicine, 1866, 518.
[2] Lancet, 1864.
[3] Am. Journ. of Med. Sci., 1861, 99.

transverse fissure. These may be enlarged when the liver has undergone cancerous, amyloid, or tubercular change. Primary cancer of the stomach may induce infiltration in the lesser omentum, and by that means compression of the bile-duct.

Causes operating at the duodenal end of the duct.—Tumor of the pancreas may either invade the duodenum and close the orifice of the common duct, or penetrate and obstruct the duct at different parts of its course, but when large, it may compress the duct from without so as to constrict or obliterate its lumen.—Cicatricial compression or ulceration may involve the duodenal orifice.

Causes operating between the hepatic and duodenal terminal orifices.—Here may be mentioned enlargement (either cancerous or tubercular) of the retro-peritoneal glands, or tumor of the omentum.

The common duct is capable of being dilated. Rokitansky gives an instance of a gall-stone the size of a hen's egg passing through the duct. The parts after such distension would naturally fail to regain their normal condition, and may permit regurgitation of fluid, as well as exit of distomata (flukes) and of hydatids from the liver to the duodenum.

Both the hepatic duct and the common biliary duct may become enormously dilated above a point of compression.[1]

The *gall-bladder* normally presents clinical relations which may be considered as of two kinds, visceral and parietal.

The *visceral* relations are with the transverse colon and the upper part of the second portion of the duodenum, answering to the point where these structures come in contact with the under surface of the gall-bladder. Frequent variations in their relative positions, however, are noticeable, and it should not be forgotten that the gall-bladder may be in contact with the first portion of the duodenum instead of the second, and in some instances with the pylorus. So the fundus may lie upon the ascending instead of upon the transverse colon, and even upon the right kidney. In instances in which the liver is pressed downward, the relations of all its parts are violently disturbed. In such cases the gall-bladder lies in contact with the small intestine.

Gall-stones are in the vast majority of cases lodged at the fundus of the gall-bladder. At the same time it must be borne in mind that any portion of the biliary apparatus may accommodate them. Thus they may be impacted in the neck of the cystic duct; they may form in the radicles of the hepatic duct in the interior of the liver; they may be lodged in the hepatic duct before its junction with the cystic duct; or they may be lodged in the common duct.

Perforation of the walls of the gall-bladder by a gall-stone need not necessarily lead to the lodgment of the concretion in the abdominal cavity. During its slow exit, sufficient inflammation may be excited to cause adhesion between the viscus and adjacent parts, and thereby to determine the appearance of the stone in any of the situations enumerated below.

It is theoretically possible for a gall-stone to enter *any* portion of the intestinal canal below the Diaphragm, as well as the renal pelvis and ureters.

Instances have been recorded of the escape of gall-stones into the colon, duodenum,[1] stomach, portal vein, pleural cavity, pelvis of kidney, and even vagina. In some rare cases in which it had been supposed, from stones having been vomited, that the perforation had occurred through the walls of the stomach, it was found after death that it had taken place through the walls of the duodenum.

The colon, notwithstanding its proximity to the gall-bladder, is infrequently selected for the exit of a gall-stone—a fact probably due to the extreme mobility of this portion of the alimentary canal. Out of seven of the recorded instances of such lesions six were due to cancerous ulceration.[2]

The *parietal* relations of the gall-bladder pertain entirely to the fundus. This commonly lies in contact with the abdominal wall, directly to the outer side of the Rectus Abdominis muscle. In enlarged conditions of the gall-bladder the fundus can be detected through the skin. Any fluctuating tumor in this position should be punctured with extreme caution. According to Hyrtl, J. L. Pettit opened such a collection in mistake for an hepatic abscess. Pagenstecker[3] describes a curious case in which laparotomy had been performed for the relief of intestinal obstruction. The gall-bladder was found adherent by its fundus to the abdominal wall near the right iliac fossa, while higher up, between the remainder of the viscus and the abdominal wall, coils of small intes-

[1] Todd, Dublin Hosp. Rep., i.

[1] According to C. Murchison, Diseases of the Liver and Gall-Bladder, 515, "the opening in the biliary passage is almost always at the fundus of the gall-bladder, but occasionally it is in the common bile-duct; *that in the duodenum is in its third or lowest division.*"

[2] Ibid., p. 516.

[3] Langenbeck's Archiv für Klin. Chirurgie, 1861, ii.

tine were found compressed at the operation. These coils were released, and the gall-bladder was secured to the parietes and opened, a proceeding which was followed by the flow of a large quantity of bile. The patient, although an old man of seventy years, recovered.—When gall-stones escape through the integument, of which 70 cases are now recorded,[1] the opening, as one would expect, is opposite the fundus. —When the gall-bladder enlarges, it may be brought in contact with the suspensory ligament, as the latter structure passes from the anterior wall of the abdomen to the liver. The peculiar origin of the suspensory ligament should not be forgotten. In some cases, a gall-stone escaping from the gall-bladder, which has previously secured adhesions to the abdominal wall, may not escape directly through the parietes, but be lodged in the suspensory ligament and be guided by it to the umbilicus. In extremely rare cases the gall-stone may descend between the muscles of the abdomen, or between them and the peritoneum to the pudenda. A calculus under these circumstances has been extracted from the submucous tissue immediately above the clitoris.[2] Such eccentric dispositions are more apt to occur when the calculus has been brought down to the umbilicus, but cannot escape thence, and is led by gravity to descend to the pubis in the wall of the abdomen, to the groin,[3] or even to the iliac fossa or the buttock. D. Hayes Agnew has found the last a site for the deposition of gall-stones. In this case, a female, fifty-eight years of age, had had an enormous cyst over the right buttock, measuring eighteen inches in either diameter. In removing the sac it was found that it led up to the crest of the ilium, and turned inward, following the curve of the iliac fossa. At the bottom of this pelvic prolongation of the sac, a nest of biliary calculi about the size of hickory-nuts was found. The previous medical history was sufficient in the judgment of Prof. Agnew to indicate that a displaced and enlarged liver had brought the gall-bladder in contact with the iliac fascia, with a subsequent escape of the gall-stones between the fascia and the Iliacus Internus muscle—the cyst in the buttock being an adventitious formation in connection therewith. —These special forms of the lesions created by gall-stones are almost peculiar to females.

THE PANCREAS.

The Pancreas (fig. 4, Plate CII.) is the largest racemose gland in the body. It is an appendage to the alimentary canal at the duodenum, and lies within the right hypochondriac, the epigastric, and the left hypochondriac regions. Long and slender, with a doubling and thickening at one end, its general form has been compared to that of a hammer; the main portion, corresponding to the "handle" of such an instrument, is called the "body;" the free portion, the "tail;" while the "hammer" proper is called the "head" of the organ.

The head (duodenal portion, vertical portion) is nearly quadrilateral in form; it lies within the median or concave border of the duodenum, to which it accurately conforms, and slightly overlaps the anterior and the posterior surfaces. The body is of a more or less prismatic form, slightly twisted upon itself; the upper, thicker border is grooved for the splenic artery and vein. The tail is thin and tapering, and is directed toward the spleen. The body and the tail are continuous, and in reality form the *horizontal portion* of the gland, while the head is quite distinct and forms the *vertical portion*. The position of the portal vein and the superior mesenteric artery and vein serves to limit these two portions.

Fig. 185.



The duodenum opened showing the valvulæ conniventes, and the opening of the common bile-duct. The duct of the pancreas is also represented in greater part of its course. *a*, duodenum. *b*, pancreas. *c*, common bile-duct. *d*, pancreatic duct. *e*, opening of the common duct in the intestine.

The pancreas measures six to eight inches in length, one-and-a-half inch in breadth, one half to one inch in thickness, and weighs from two and a half to four and a half ounces. Its texture is somewhat looser than that of the salivary glands, but is at times, particularly in thin persons, of a peculiar density.

Extending throughout its entire length, concealed within the substance of the gland, but lying nearer the lower border, is the excretory duct.

The excretory duct (duct of Wirsung) usually joins the common bile-duct, and empties into the duodenum with the latter. The manner of termination of the

[1] Murchison, l. c., 521.
[2] Gaz. des Hôp., Oct. 8, 1846.
[3] Murchison, 522.

pancreatic duct has been the cause of much discussion. The following arrangement of parts may be considered the average one: Both the pancreatic duct and the common bile-duct joining at an acute angle present their terminal orifices within a little chamber or cloaca (ampulla of Vater), lined with mucous membrane, and terminated by a teat-like contraction within the duodenum. In its absence, which is unusual, the pancreatic duct empties into the duodenum, while the common bile-duct finds a separate outlet by its side.

An accessory duct (duct of Santorini, azygos canal) from the lower portion of the head of the gland often opens by a separate opening into the duodenum. It anastomoses with the main duct so that a stream of water thrown into the main duct from the duodenum will in part escape by the mouth of the accessory duct.

Relations.—The pancreas, like a salivary gland, adapts itself to the inequalities of the region it occupies. The vertical portion, as already noted, is fixed to the nearly immovable middle third of the duodenum, where it is in close relation to the mesentery. The horizontal portion of the organ is more movable, and is said to "float." Owing to the disposition of the splenic vein, this portion follows to a slight degree the motions of the spleen, the stomach, and the Diaphragm. The tail thus tends to lie a little above the horizontal line, and the "head" a little below. The entire organ is slightly arched, the convexity being directed in front.

The pancreas lies opposite to the twelfth dorsal vertebra, although it may be found as low down as the second lumbar, or as high up as the eleventh dorsal. In emaciated individuals the pancreas can be readily outlined by palpation, and care should be taken not to confound the healthy organs thus determined with abdominal tumor.[1] The posterior wall of the omental sac alone intervenes between the pancreas and the anterior abdominal wall when the stomach is depressed, as in prolonged fasting. In repletion the stomach lies directly in front of the organ. Behind it are the aorta, pillars of the Diaphragm, thoracic duct, vertebral column, kidneys, and the supra-renal capsules. The lobus Spigelii and the inferior vena cava lie behind the head. As already seen, the middle portion of the duodenum lies to the right side, and the spleen to the left. The horizontal portion is grooved above by the splenic vein, and posteriorly from below upward by the portal vein and the superior mesenteric artery.

A. Cooper[2] found, after the ligation of the thoracic duct in dogs, that the pancreas was forced forward. It is probable that a similar change in position may ensue in the human subject after obstruction in the abdominal portion of the thoracic duct.

[1] Med. Times and Gaz., 1869, Jan. 16.

[2] Med. Rec. and Repositor, 1798, 86.

Bloodvessels.—The arteries of the pancreas are numerous minute branches derived from the splenic, as well as from the superior pancreato-duodenal, the inferior pancreato-duodenal, and the superior mesenteric arteries. The gland is grooved posteriorly by the superior mesenteric artery; the artery may perforate the gland structure much after the plan by which the internal maxillary artery perforates the parotid gland. The *venous blood* returns by the splenic and superior mesenteric veins. In enlarged conditions of the pancreas both the arteries and the veins may be compressed.

Nerves.—The nerves are derived from the branches of the cœliac axis.

Lymphatics.—The lymphatics terminate in the lumbar vessels and glands.

Variations.—The horizontal portion may be sigmoid instead of straight. The vertical portion is bulkier in the adult than in the young individual, and embraces to a greater degree the duodenum. The splenic vein may infrequently follow the inferior border of the horizontal portion instead of the superior. The groove for the mesenteric vessels may be converted into a canal.—The head of the gland is often separated from the body by a deep fissure. In the instances in which the pancreas is completely divided at this point the head has received the name of the *lesser pancreas.* Under these conditions a distinct duct is seen ascending and commonly joining the main duct near its termination.—The common bile-duct lies either within a complete canal of pancreatic tissue, or at least in a deep notch in the posterior part of the head of the pancreas.[1]

Remarks.—The clinical study of the pancreas embraces the relations borne by the gland to the other organs of the epigastric and hypochondriac regions and to the peritoneum. At the risk of repeating the relations above cited, it may here be said that the pancreas from its position across the abdomen involves by its right extremity the liver, and is in clinical relation with the ascending portion of the duodenum; by its middle portion with the superior mesenteric artery and vein, and the greater part of the stomach, the aorta, and the thoracic duct; and by its left portion with the spleen. The peritoneum is more intimately associated with the pancreas at its right extremity than with either the left extremity or with the middle portion.

The relations of the pancreas can be recalled to advantage in studying many of its morbid states. A

[1] A. Verneuil, Comptes Rendus des Séances et Mem. de la Soc. de Biologie, 1852, iii. 136.

tumor directly above the stomach at the epigastrium may be a cancer of the pancreas, which has forced the stomach downward. The stomach may be adherent to the pancreas, or the latter may even fill up an opening in its walls. The head of the pancreas in diseased conditions may so compress the common bile-duct as to induce icterus, and, by obstruction of the pancreatic duct, cause derangement of the proper pancreatic secretion.

When a morbid growth involves the common duct of the pancreas, the tributaries of the duct behind the point of obstruction rarely become sufficiently dilated to attract attention. In a case narrated by J. S. Bristowe, it was found that obstruction of the common bile-duct, which was distended to the size of the duodenum, was associated with enlargement of the pancreas. The pancreatic duct was dilated to a remarkable degree. The main portion pursued a tortuous course the entire length of the gland, and exhibited a diameter large enough to admit the tip of the little finger. The lower ends of the hepatic and pancreatic ducts were involved in a mass which was probably inflammatory.—In another instance recorded by the same writer, a cyst holding from two to three ounces of a colorless transparent fluid was found lodged in the small omentum, and was regarded as a result of pancreatic obstruction.[1]

The head of the pancreas may by enlargement compress the duodenum,[2] and the aorta. Enlarged conditions of the pancreas may compress the lacteals, or may in turn be displaced forward by the distension of the thoracic duct *supra* or by the enlarged retro-peritoneal lymphatic glands.[3]

Cancerous growths, by increasing the size of the pancreatic mass, may cause it to assume relations not entertained in a normal condition. Among the parts so related may be mentioned the colon at the hepatic flexure, the liver, and the structures at its transverse fissure. The diseased mass may embrace the duodenum, press on the pylorus, or rarely surround the lesser curvature of the stomach. The exemption of the spleen, supra-renal capsules, and the kidneys from these encroachments is very striking.—The pancreas putrefies readily.

THE PERITONEUM.

The Peritoneum (fig. 1, Plate C.) is the serous membrane which lines the abdominal cavity. It aids in supporting the abdominal viscera, defines the pelvic contents superiorly by the secretion of serum, facilitates the motions of the organs among themselves, and aids in maintaining the patulency of the alimentary canal and various gland-ducts.

The most extensive of serous surfaces, it differs from others of its class in possessing in the female two openings of communication with mucous membrane, viz., those of the Fallopian tubes, through their free extremities.

The inner surface of the peritoneum is smooth and covered with flattened, tessellated epithelium; the outer is rough and is in relation with connective tissue.

The cavity defined by the peritoneum is called the *peritoneal cavity*, and is divided into the greater and lesser cavities, as will be described further on.

The peritoneum as it lines the walls of the abdomen is called the *parietal* portion, and where it is in contact with the abdominal contents it is called the *visceral* portion. A viscus (as, for instance, the pancreas) lying close to the posterior wall of the abdomen may receive but a small surface of contact, when it is said to be imperfectly invested by peritoneum; but when the organ lies further forward, the surrounding peritoneum is said to invest it completely. In an exact sense the peritoneum, however, in no case completely embraces any organ, an appreciable interval existing between the sides of the loop permitting arteries to enter, and veins and lymphatics to escape. Fat is very liable to accumulate in such localities. When this becomes abundant and the colon is contracted, the operation of colotomy becomes very difficult to perform.[1]

The *sub-peritoneal* connective tissue in the posterior and lower portion of the abdomen is exceedingly loose and abundant; but is compact in the anterior and diaphragmatic walls, and as a rule is sparse and firmly united to the intestine. It is continuous above with the subpleural connective tissue, through the œsophageal and aortic openings in the Diaphragm, and below with the pelvic connective tissue and fasciæ. It also escapes from the crural canal and joins the connective tissue of the thigh.

Beginning the description at the umbilicus, it is found that the peritoneum passes from that point to the Diaphragm, from which it is reflected to the upper surface of the liver, where it assists in forming the lateral ligaments. The remains of the umbilical vein are in this region held within a fold of peritoneum,

[1] St. Thom. Hosp. Rep., 1873, 141.
[2] Fletcher, Birmingham Path. Soc.; Prov. Med. Journ., 1844.
[3] Bright, Med.-Chir. Trans., 1833, xviii.

[1] Curling, Diseases of the Rectum, 4th ed., 180.

which has received the name of the *suspensory* or *longitudinal ligament*. This structure is of a triangular shape, its apex being below at the umbilicus, and its base above at the upper surface of the liver, where it serves to limit the right and left lobes. Passing from the upper to the under surface of the liver the membrane covers in the gall-bladder, and, reaching the transverse fissure, it is deflected downward and to the left upon the stomach, forming the *anterior layer* of the *gastro-hepatic omentum*.

Reaching the stomach the membrane passes over its anterior aspect, embracing at the same time the spleen. Between the stomach and the spleen a short but stout duplicature has received the name of the *gastro-splenic omentum*. It carries the vasa brevia and the splenic vein.

From the stomach it passes to the great omentum, the outer surface of which it defines, and is carried upon the posterior surface of the omentum upward toward the transverse colon, and thence above this portion of the intestine back to the vertebral column.

The *great omentum* is a large apron-like structure commonly loaded with fat, extending along the greater curvature of the stomach, and descending in front of the intestine. On the right side the base is continuous with the *hepatico-colic ligament*, where a fold is seen. The lower free margin of the omentum tends to be slightly prolonged. Hernial protrusions containing omentum are more common on the left side.

The peritoneum thence passes down in front of the duodenum, the aorta, and vena cava, to be again projected to form a loop of great extent embracing the jejunum and ileum, and is known as the mesentery. The *mesentery* is at its root about six inches in length, and is directed obliquely downward and to the right from the second lumbar vertebra to the right sacro-iliac junction. Owing to this circumstance, the mass of small intestine inclines to the right side, and is thus a more frequent ingredient of right inguinal hernia than is the left. In placing the pad of a truss adapted to the right side of the groin it is recommended to turn the patient upon the left side with the object of relieving the right inguinal canal from the pressure of the intestinal mass.

The cæcum and vermiform appendix are next invested by the peritoneum, which then covers the anterior two-thirds or five-sixths of both the ascending colon and the descending colon, and defines a short and in some respects imperfect ascending and descending meso-colon.

From the vertebral column the peritoneum is projected to form a loop sustaining the transverse colon, which loop has received from this relation the name of the *transverse meso-colon*. This structure lies beneath and in close relation with the posterior layer of the great omentum. Formerly the omentum was described as inclosing the transverse colon.

From the sigmoid flexure the peritoneum passes to the upper portion of the rectum, behind which is a small fold, the *meso-rectum*. The membrane, however, soon leaves the rectum, first at the sides, and finally in front, so that the greater portion of the gut is without peritoneal covering.

The pelvic layer of the peritoneum in the male exhibits two folds extending from the rectum to the bladder. These are called the *recto-vesical folds* (plicæ semilunares), and define laterally the *recto-vesical* fossa.

In the female the above folds are absent. The bladder and uterus are, however, connected by a pair of lateral folds, the *vesico-uterine* folds, while the *uterus* and *rectum* are joined by an analogous pair called the *recto-uterine* (utero-sacral) folds. The peritoneum is in contact with a small portion only of the posterior wall of the vagina. In addition to these the body of the uterus is embraced by the *broad ligaments* at the same time that the ovaries and Fallopian tubes are held laterally by the *infundibulo-pelvic ligaments*.

The pelvic layer, after covering the summit of the bladder, passes to the anterior wall of the abdomen. At the inguinal region it presents two shallow pits or fossæ (Foveæ inguinales). The internal of these answers in position to the external abdominal ring; the external to the internal abdominal ring. The latter is the seat of the fœtal prolongation carrying the testis in its descent from the abdomen to the scrotum in the male. In the female the internal abdominal ring accommodates the canal of Nuck.

Extending from the sides of the bladder upward along the abdominal wall to the umbilicus is a pair of cord-like bands answering in position to the hypogastric arteries of the fœtus. They are in consequence known as the *remains of the hypogastric arteries*. Extending vertically upward from the summit of the bladder to the umbilicus is a somewhat similar cord which answers to the *remains of the urachus*.

The deep epigastric artery of either side, as it passes upward between the inguinal fossæ, creates a small peritoneal fold, the *plica epigastrica*.

Reviewing the description from its starting-point, viz., the umbilicus, it will be seen that a large cavity has been described (the greater peritoneal cavity), which does not cover the *posterior* wall of the stomach and adjacent surfaces. This second, smaller

cavity has received the name of the *lesser peritoneal cavity*, and will be now described.

In order properly to do this it is necessary to turn for a moment to the development of the parts. The stomach, as is the case with the other abdominal viscera, is received in a loop of peritoneum projected from the vertebral column. The pedicle of this loop has received in the fœtus the name of the *meso-gastrium*.[1]

At the fourth or fifth week, when the *meso-gastrium* performs a duty analogous to the mesentery, the stomach is placed vertically in the abdomen. As the pyloric end is deflected to the left, the *meso-gastrium* gradually undergoes a great change. It is carried by the stomach from the posterior toward the anterior wall of the abdomen, and sags downward so as to hang in front of the intestine, and forms the *great omentum*.

It will be seen that a cavity, lined with peritoneum—the lesser cavity of the peritoneum[2]—lies between the stomach and the vertebral column. It is continuous with the interior of the great omental loop below and extends along the gastro-hepatic omentum from its posterior layer to the lesser curvature of the stomach, and thence covers the posterior surface of this organ. From this point it passes within the great omentum, and forms its *inner* layer. Along the back of the lesser cavity it covers in the pancreas and portions of the spleen and the Diaphragm. It ascends upon the latter and is reflected thence upon the liver, and from this organ in turn to the posterior layer of the gastro-hepatic omentum. The lesser peritoneal cavity communicates with the greater peritoneal cavity by an opening between the stomach and the liver called the foramen of Winslow. The *foramen of Winslow* is an aperture bounded behind by the vena cava, in front by the hepatic vessels, above by the lobe of Spigelius as it joins with the caudate lobe, and below by the duodenum. It is probably originally created by the traction of the liver through its common bile-duct, at the time of the deflection of the stomach toward the right side. It generally measures an inch in diameter. This measurement is less when the stomach is distended.

The lesser cavity can be inflated in the infant. Later in life the great omentum becomes here and there perforated, when inflation is no longer possible.

Nevertheless, the cavity may be occupied by fluid in the adult (forming the abnormal condition known as *Hydrops saccatus*) through occlusion of the foramen of Winslow.

Peritoneal folds. In consequence of the intricate arrangements obtained in applying a serous membrane to such varied surfaces as those of the abdominal cavity, a number of folds (ligaments, plicæ) are formed. Some of these have already been described. But to insure ease of reference the complete list is herewith given.

(1) The suspensory ligament of the liver, determined by the position of the umbilical vein.

(2) The right and left lateral ligaments of the liver.

(3) The gastro-splenic omentum, ligament, or fold.[1]

(4) The gastro-phrenic ligament.

(5) The costo-phrenic fold. This originates from the Diaphragm opposite the tenth to the twelfth rib, passes to the splenic flexure of the colon, thence over the splenic flexure, and reaches the left kidney and the descending colon.

(6) The hepatico-renal fold.

(7) The recto-vesical, recto-uterine, vesico-uterine folds, and infundibulo-pelvic ligaments.

(8) The ileo-cæcal fold.

(9) The mesenterico-meso-colic fold. This is described as lying between the mesentery and the meso-colon of the sigmoid flexure. It would appear to limit the descent of the latter.[2]

Peritoneal Fossæ.—In addition to the above folds five fossæ (peritoneal pouches, peritoneal pits) have been described.

(1) *The duodeno-jejunal fossa.*—The duodeno-jejunal fossa (fossa duodenalis) lies to the left side of the third lumbar vertebra between the pancreas, the left kidney, and the aorta. It has the capacity of a walnut, and presents its orifice forward. The upper margin is lost in the lower leaf of the transverse meso-colon; it contains the inferior mesenteric vein. The lower is produced upon the peritoneal covering of the duodenum, and contains the left colic artery. The pouch is ordinarily occupied by the junction of the duodenum with the jejunum. (Luschka.) Treitz[3] has described cases of hernia situated in this locality under the name of *hernia retro-peritonæalis*, *i. e.*, hernia into the retro-peritoneal space. Montard[4] gives a case of congenital retro-peritoneal sac. At the autopsy a bladder-like mass, of the size of a child's head, was seen at the back part of the abdomen, covered with a thin, smooth, and perfectly transparent coat, presenting all the appearances of the peritoneum. It was found when opened to contain a knuckle of the small intestine. The foramen of Winslow was absent, and the stomach was in its primitive fœtal position. The

[1] J. Müller, Meckel's Archiv, 1830, 411, Taf. xi., figs. 1–10.

[2] See the dark-shaded space in fig. 1, Plate C.

[1] See, in connection with this subject, The Peritoneal Covering of the Spleen and the Lig. Pleuro-colicum. (Archiv für Anat. und Phys., etc., 1867, 565, Taf. xvii. A.)

[2] Gruber, Zeitschrift der k. k. Gesellschaft der Aertze zu Wien. Vierter Jahrg. Bd. ii., 432.

[3] Ein Beitrag zur Geschichte inner. Hernien.

[4] Union Médicale, No. 93, 1869, cited in N. Y. Med. Journ., xii. 230.

patient did not exhibit at any time symptoms of intestinal obstruction. The cause of death was typhoid fever.[1]

(2) *The sub-cæcal fossa.*—The sub-cæcal fossa is a pocket situated behind and below the cæcum. Very often it is but a shallow depression, but it may be as long as one's fingers, when it is directed upward between the layers of the meso-colon. It is stated by Luschka that hernia may be situated at this position.

(3) *The ileo-cæcal fossa.*—The ileo-cæcal fossa lies between the opposed sides of the cæcum and the end of the ileum.

Its size is variable, but generally is that of the thumb-nail.[2]

It was reserved for Schott[3] to direct attention to the fact that this pouch is sometimes the seat of a cystic growth, which, by pressure upward, may occlude the ileo-cæcal aperture, and induce fatal intestinal obstruction.

(4) *The inter-sigmoid fossa.*—This is the name given by Luschka to the small pouch developed from the left leaf of the meso-colon of the sigmoid flexure. It is inconstant and of variable size. It appears to be the least important of the peritoneal fossæ.

(5) *The recto-vesical fossa* lies between the rectum and the bladder in the male. It is about four inches above the anus.

Variations.—The *meso-rectal fold.*—The mass forming the body of a prolapsed rectum is often tilted forward or to one side, and the intestinal aperture assumes the form of a fissure, receding from the surface of the tumor, owing to the traction exerted upon it by the meso-rectum.

A congenitally misplaced kidney may have a distinct meso-nephron.[1]

An anomaly, recalling the period in fœtal life at which the small and large intestines are arranged near the median line, has been recorded by Gruber,[2] in which the large and small intestines of an adult were held in complete connection by a common mesentery.

Appended to the peritoneum here and there are pedunculated tags or pouches of peritoneum containing fat. These are called *appendiculæ epiploicæ*, and though common along the course of the transverse colon, are of unknown function.

The attachments of the peritoneum which have clinical significance.—The degree of firmness of attachment of the peritoneum to the different organs varies. The membrane is loosely attached to the organs in the retro-peritoneal space, but firmly to the intestines. It is capable of undergoing marked changes of relation. Thus the gravid uterus, ovarian tumors, and hernial protrusions will appropriate peritoneum from adjacent points,—the uterus and ovaries from the broad ligaments and their related folds; the hernial sacs from the inguinal fossæ and bladder. The degree of this appropriation depends, it would seem probable, upon the rate of growth in the mass. Thus a rapidly growing tumor, or rapidly distending viscus, will adapt to itself the loose membrane from adjacent parts.

When the growth or viscus increases in size slowly, the peritoneum may grow *pari passu* with the other elements of new structure. In a greatly distended urinary bladder the fundus may reach to within one inch and a half of the ensiform cartilage. The reflexion of the peritoneum from the fundus to the abdominal wall in such a case would be within an inch of the umbilicus.

In rupture of the uterus the peritoneum will frequently resist the direct effects of the lesion; and hemorrhage into the peritoneal cavity need not result from this accident.

In the operation of ovariotomy the peritoneum may be easily stripped from the ovarian cysts when these growths have simply appropriated as coverings

[1] For other cases with figures see Trans. Path. Soc. Lond., 1865, 139; and Peacock, ibid., ii. 60.

According to R. J. Anderson, the fossa duodenalis is limited above by the posterior layer of the transverse meso-colon, internally (medianly) by the duodenum, and bounded at the left by a sharp falciform marginal fold. The aorta lies medianly and behind. It may have an extent of two inches from above downward, and an inch in depth. In the fold mentioned the left colic artery may be found, and according to some writers the inferior mesenteric vein. The vein last mentioned may also be crossed by this artery below the fold. From one to two inches of intestine lie within the fossa.

The fossa is caused (in the language of the same writer) as follows: "At a time when the liver is large and occupies both hypochondria, the alimentary canal is mesial (*i. e.* in the middle line). When the liver becomes smaller (relatively), and comes to occupy the right hypochondrium, the pyloric end of the stomach and the duodenum are drawn to the right, the upper and lower transverse parts of the duodenum being thus produced. The peritoneum in the neighborhood of the duodeno-jejunal flexure is also drawn to the right side; and in this way, in consequence of the loose tissue beneath the posterior abdominal peritoneum in that situation, the fossa and the plica duodeno-jejunalis are produced. The movement of the colon does not compensate for the movement of the duodenum, but rather tends to throw into relief the prominent border of the fold."—Journ. Anat. and Phys. 1878, 237.

[2] Luschka, Ueber die peritonæale Umhüllung des Blinddarmes und über die Fossa ileo-cæcalis, Virchow's Archiv, vol. xxi., 1861, 285, Taf. iv. f. 3.

[3] Beiträge zur Anatomie der Fossa ileo-cæcalis, Wochenblat der Zeitschrift der k. k. Gesellschaft der Aertze in Wien, 1862, No. 44.

[1] A. E. Durham, Guy's Hosp. Rep., iv. 1860, 420.

[2] Beiträge zur den Bildungshemmungen der Mesenterien; Archiv f. Anat. Phys. und Wissenschaft. Med., 1862, 588, Taf. xv. fig. 1, 2. See, also, on the presence of a common mesentery for the jejunum and ileum, and the initial half of the large intestine, accompanied with lateral transposition of the viscera, Ueber das Vorkommen eines Mesenterium commune für das Jejuno-ileum und grossere Anfangshälfte des Dickdarms, etc. Ibid., xiv. 1865, 558.

the adjacent loose folds extending from them to the pelvis; while, on the other hand, the firmer union existing between the peritoneum and the anterior abdominal wall renders it difficult under certain conditions to distinguish the membrane from the firm sub-peritoneal fibrous layers. It is recommended by W. Atlee, of Philadelphia, under such circumstances to insert the hand in the wound, and pass it upward to the region of the umbilicus. If the membrane in question be peritoneum, it will of course be free at the position of the umbilical cicatrix, while, if it be a part of the abdominal wall, it will be attached there.

The Retro-Peritoneal Space. The retro-peritoneal space (*supra*) is a name frequently given to the region between the peritoneal cavity and the vertebral column. An analogous region is found in the posterior mediastinum. It is occupied by the kidneys, suprarenal capsules, pancreas, some of the ganglia of the sympathetic nerve-trunk, lymphatic glands, abdominal aorta, inferior vena cava, thoracic duct, and, in the fœtus, by the testis or the ovary.

Partially exposed within it are the descending and transverse portions of the duodenum, and the ascending and descending colon. The cæcum is also commonly uncovered along its posterior border toward the space; but this portion of the canal may be completely covered with peritoneum.

Remarks.—The retro-peritoneal space is thus a great sac or hiatus within which many diseased processes originate and rapidly spread. The lymphatic glands may here assume enormous proportions, aneurism in the abdominal aorta may occur, and when blood escapes into the space either from bursting of an aneurism or from purpura, it meets with no resistance until the boundaries of the space are reached. (See p. 305.)

The escape of blood, such as that from an aneurism, into the *sub-peritoneal* connective tissue of the abdomen, may compress the cardiac extremity of the stomach and induce dysphagia. If the rupture occurs lower down, it may involve the space between the layers of the great omentum, that between the transverse colon and the spine, and that in front of the pancreas and round the third part of the duodenum. The last structure may become in consequence compressed and obstructed.[1]

According to J. Hilton,[2] the swelling over a ruptured kidney cannot reach beyond the middle line of the vertebral column. The serous membrane is attached to the vessels in front of the spine, and limits the spread of the extravasation. In rupture of the abdominal aorta, however, beneath the peritoneum, the blood usually spreads equally on both sides of the spine.[1]

The retro-peritoneal space will also afford opportunity for the pus from an empyema to pass downward along the posterior wall of the abdomen, and for the pus of a psoas abscess to ascend to enter the thorax.

The retro-peritoneal space is of great interest to the physician. Morbid processes excited within it are not limited by any well-defined boundary. Blood effused within it can traverse its entire length and even pass upward into the posterior mediastinum, or escape between the layers of the great omentum, between the transverse colon and the spine, in front of the pancreas, or around the transverse portion of the duodenum, which may thus be compressed. Collections of pus in this locality may be either diffused or circumscribed. Such collections may occur at any portion of the space, and may often accompany organic disease. They may be due to transmitted irritation from the bowel or from muscular strain. The two latter causes are more frequently operative along the ascending and the descending colon. An abscess has been detected external to the sigmoid flexure. The most frequent form of such collections is that which occurs behind the ascending colon, particularly at or near the cæcum. Iliac abscess or suppurative perityphlitis excites profound disturbance in the loose texture of the retro-peritoneal space. The pus which successively forms in it as the tissue breaks down may rupture the sheath of the Psoas muscle, perforate the Diaphragm, or reach the thorax through the aortic opening. It may also perforate the great vessels lying within the space, particularly the internal iliac artery and vein.

The omentum may be adherent to the anterior wall of the rectum, where by an unusual coincidence it has aided in closing a perforating ulcer into the peritoneal cavity.[2]—The lace-like interstices in the omentum have been known to receive knuckles of

[1] J. S. Bristowe, Trans. Path. Soc. Lond., 1859, x. 88; also 1860, 89.

[2] Guy's Hospital Reports, 1867, 21.

[1] For literature of involvement of the retro-peritoneal space, see J. Chiene, Journ. Anat. and Phys., ii. 218; P. H. Pye-Smith, Guy's Hosp. Rep., 1871, 131; Waldeyer, Virchow's Archiv, lx.; also in Glasgow Medical Journal, 1874, 543; J. P. Irwine, Trans. Path. Soc. London, xxix. 1878, 85.

[2] T. B. Curling, Diseases of the Testicle, p. 111.

intestines and cause obstruction.—In the bursting of abdominal aneurism, the cavity of the great omentum may be injected with blood.[1]

A portion of the omentum may protrude in penetrating wounds of the abdomen, an event that may follow even upon paracentesis.[2] It may be a constituent in hernia, in which form it may be either diaphragmatic or scrotal.[3] Niemann[4] records a case in which a fold of omentum was caught and held in a traumatic fissure of the liver.

Fat is absent in the mesentery prior to the seventh or the eighth month of fœtal life. This fact has been thought sufficiently exact to be of value in determining the age of the embryo, and in this way has been used in forensic medicine.[5]

The Organs of Respiration.

Under the head of the Organs of Respiration will be described—

The Larynx.
The Trachea.
The Bronchi.
The Lungs.
The Pleura.
The Mediastinal Spaces.

THE LARYNX.

The Larynx (Plates CIII., CIV.) is the organ of voice. It is that portion of the respiratory tract intervening between the pharynx and the trachea. The larynx lies opposite the fourth and fifth cervical vertebræ, and forms the most conspicuous feature in the regional anatomy of the neck, situated as it is between the pharynx behind, and the integument and the thyroid body in front. Above the larynx lies the hyoid bone. The organ is slightly movable from side to side.

The larynx extends from the second to the fifth or sixth cervical vertebra.

The description of the larynx embraces—

The Cartilages.
The Ligaments.
The Muscles.
The Interior of the Larynx.

[1] Young, N. Y. Journ. Med., 1849, 201.

[2] W. H. Van Buren, N. Y. Journ. of Med., 1849, 333.

[3] J. R. Woodworth, N. Y. Med. Journ., xix. 402: also S. S. Smith, N. Y. Journ. of Med., 1851, 218.

[4] Henke's Zeitschr. für die Staatsarzneikunde, B. 74, 1857.

[5] Henke, ibid. vii. 1844; abstract in Am. Journ. Med. Sci., 1845, 245.

The Cartilages of the Larynx.

The Cartilages of the Larynx are five in number—

The Cricoid.
The two Arytenoids.
The two Cartilages of Santorini.
The two Cartilages of Wrisberg.
The Thyroid.
The Cartilage of the Epiglottis.

THE CRICOID CARTILAGE.

The Cricoid Cartilage is placed between the trachea below and the thyroid and arytenoid cartilages above. The thyroid embraces the cricoid cartilage; the arytenoids surmount it. The cricoid cartilage is thicker and stronger than the thyroid, and is extended upward behind, where the thyroid is deficient. It is, as the name expresses, a ring-like cartilage, the anteroposterior diameter being a little longer than the transverse. The anterior part is much smaller than the posterior. The lower border is horizontal and sinuous, while the superior gradually ascends as it passes backward. Toward the upper posterior portion lies a conspicuous rounded facet for articulation with the inferior horn of the thyroid cartilage. On either side of the upper border is an oval eminence directed upward and outward, for articulation with the arytenoid cartilage. The posterior surface is divided in the median line by a slight vertical ridge, which serves as a partial attachment for the œsophagus, while on either side lies a well-defined but shallow depression for the Posterior Crico-Arytenoid muscle. The anterior surface is convex, and affords origin to the Crico-Thyroid muscles, and to part of the Inferior Constrictor. The lower border is slightly produced in front. The mucous membrane lining the cartilage is intimately adherent to the perichondrium.

THE ARYTENOID CARTILAGES.

The Arytenoid Cartilages are two in number. They are situated upon the posterior lateral portion of the upper border of the cricoid cartilage, and within the grasp of the thyroid cartilage. They are the most movable of the laryngeal cartilages, and are important factors in the mechanism of speech. Each cartilage is from five to six lines in height, three lines in width, and one in thickness. The general form of each is that of a pyramid, whose apex is curved inward, so that the upper inner borders approach and may even touch one another.

When at rest, the arytenoid is inclined slightly forward, and presents for examination three surfaces, a posterior, median, and anterior; and also a base and an apex.

The posterior surface is triangular, smooth, and concave for the partial attachment of the Arytenoid muscle. The median surface is narrow, but wider below than above. It presents a nearly vertical surface, which is covered by the laryngeal mucous membrane, and serves to limit each side of the inter-arytenoid space. The anterior surface is at the same time directed slightly outward. It is irregularly convex, and is roughened for the attachment of the thyro-arytenoid ligament.

The details of structure upon the anterior surface are more numerous than upon the others, and may be briefly epitomized as follows: At the upper part of the posterior border a slight eminence is seen which is known as the *colliculus* or superior spine. Below the colliculus lies a depression known as the *deltoid fossa*, beneath which, but ascending to define its posterior wall, is an *arched crest* (crista transversa) or inferior spine. Adjacent is seen an oblong depression (fovea oblonga) for the insertion of the Thyro-Arytenoid muscle. The colliculus can sometimes be seen within the laryngeal image as a slight eminence above the laryngeal pouch.

The *base* presents a deeply arched concavity for articulation with the eminence upon the cricoid cartilage. The posterior end of the base is slightly prolonged, and strengthened on the posterior surface to form the musculo-articular process (tubercle) for the insertion of the Crico-Arytenoid muscle. Anteriorly the line of the base is extended beyond the articular facet, which forms a pyramidal process known as the *vocal process*. The vocal process is a conspicuous feature in the outline of the *rima glottidis* as seen in the laryngeal image. It is estimated that its length is from one-third to one-fourth that of the antero-posterior diameter of the glottis. The *apex* of the arytenoid cartilage is formed by a small obliquely-placed plane, to be studied in connection with the following structures.

THE CARTILAGES OF SANTORINI.

The Cartilages of Santorini are conical or cylindrical nodules of fibro-cartilage, which are situated at the upper part or apex of the arytenoid cartilages. They are freely movable, and are, as a rule, united with the arytenoids by synchondrosis, although they may be, according to Cruveilhier, distinct. They form, when covered with mucous membrane, conspicuous rounded eminences upon the posterior margin of the laryngeal aperture.

THE CARTILAGES OF WRISBERG.

The Cartilages of Wrisberg are small, rod-like, or wedge-like nodules of fibro-cartilage, which are lodged between the layers of the aryteno-epiglottic fold, and which are surrounded by mucous glands. The inner extremity commonly projects above the free border of the fold, a little to the outer side of the eminence of the cartilage of Santorini.

G. D. Gibb[1] found the cartilages of Wrisberg larger in the negro race than in the white.

Luschka has described a minute inconstant nodule of cartilage named by him the *sesamoid cartilage*, which is held by a ligament to the outer margin of the arytenoid, between that body and the cartilage of Santorini. He has also directed attention to a pair of minute inconstant structures (Luschka's cartilages) upon the vocal cord near its insertion into the thyroid cartilage. He names the first the *posterior sesamoid* and the second the *anterior sesamoid cartilage*. He mentions the rare existence of a small nodule of cartilage which he names *inter-arytenoid*. It lies upon the posterior aspect of the pharynx, directly beneath the mucous membrane, and is connected to the cartilage of Santorini above by a pair of fibrous cords, and below by a single cord which unites it to the upper border of the cricoid cartilage. Luschka refers to a case in which, owing to its unusual development, a prominence due to the presence of this cartilage was visible in the laryngeal image, and was mistaken for an abscess.

Mucus and other fluids are guided by the posterior boundary of the superior laryngeal aperture to the sides of the pharynx and œsophagus. Thus a single current of a liquid passing downward from the mouth divides into two streams which subsequently commingle in the œsophagus below the larynx.

THE THYROID CARTILAGE.

The Thyroid Cartilage, so called from its resemblance to a shield, incloses and protects the essential parts of the vocal apparatus. It is a symmetrical body, presenting two flanges (alæ, sides), which are arranged at an acute angle to each other like the divergent parts of a half-opened screen.

The re-entering angle is placed in the median line, while the sides are directed backward and outward. Each side or wing is quadrangular, and presents for examination an external and an internal surface as well as four borders and two cornua.

The *outer surface* is marked by an oblique line which extends between two marginal tubercles; one of these is situated upon the posterior border at its upper third, the other upon the inferior border. This ridge separates the anterior three-fourths from the

[1] Anthrop. Rev., 1864, 322.

posterior fourth. The Sterno-Thyroid, Thyro-Hyoid, and Inferior Constrictor muscles are attached to this ridge. The smooth surface behind and below it lodges in part the thyroid body. Near the upper border of the outer surface, not far from the base of the greater horn, a foramen is occasionally seen for the transmission of the superior laryngeal artery.

The *inner surface* is smooth and slightly concave. It is related above with the mucous membrane of the pharynx, behind and below with the lateral Crico-Arytenoid muscle.

The *upper border* is larger than the inferior. It is concave directly in front of the base of the greater horn, but convex toward the inner margin, thus making for the entire border a sigmoid curve. At the union of the upper borders of the two plates a deep notch is seen which has received the name of the *thyroid incisure*. The upper border gives attachment to the thyro-hyoid membrane. The *lower border* is wavy, and gives attachment to the Crico-Thyroid muscle, at the sides, as well as to the crico-thyroid membrane. The *posterior border* is free, rounded, and is continuous upward with the corresponding border of the cornu. It gives attachment in part to the Inferior-Constrictor, Stylo-Pharyngeus, and Pharyngo-Staphylinus muscles. The *anterior* border joins the plate of the opposite side.

The *superior cornu* is much larger than the inferior, and is directed upward and slightly backward. Its free extremity affords attachment to the thyro-hyoid ligament. The *inferior cornu* is thick and stout. It is furnished upon its inner surface with a facet for articulation with the cricoid cartilage.

The conjunction of the two plates anteriorly forms the prominence known in the adult male as *Adam's apple*. In the female and in children of both sexes this prominence is less pronounced, and the angle of the plates is less acute than in the adult male. Viewed from behind, the re-entering angle of the two plates presents the following features: First, the upper part for the attachment of the epiglottis, and false vocal cords. Second, the middle part for the attachment of the true vocal cords. Third, the inferior part for the attachment of the Thyro-Arytenoid muscle.

Between Adam's apple and the skin lies a bursa, which ascends perpendicularly to a point near the hyoid bone, and then passes behind it. This bursa is congenital, and apparently belongs to the thyro-hyoid membrane rather than to the thyroid cartilage. It facilitates the gliding of the thyroid cartilage over the anterior border of the hyoid bone. — A bursa has been described lying between the thyroid cartilage and the hyoid bone. It is occasionally the seat of hypertrophy. This condition has been named "thyro-hyoid cyst" by Gibbs, "sub-hyoidean ranula" by Nélaton, and "hyoidean hygroma" by Mackenzie.

THE CARTILAGE OF THE EPIGLOTTIS.

The Cartilage of the Epiglottis is a vertical, leaf-shaped lamina of fibro-cartilage situated at the front of the larynx. It is broad above and narrow below, where it is attached by a portion of the thyro epiglottic ligament to the re-entering angle of the thyroid cartilage. It is also attached in front at its basal portion to the hyoid bone, to the hyo-epiglottic ligament, and to the base of the tongue, so that its free surfaces are restricted to the posterior aspect and the superior half, nearly, of the cartilage, which is there partially invested with mucous membrane.

The first of the free surfaces constitutes the anterior border of the laryngeal aperture; while the second lies at the base of the tongue.

The posterior surface (laryngeal surface) is concave above, but convex below, where it presents a rounded eminence, the tubercle or cushion. The anterior surface is slightly concave. The margins are for the most part obscured by folds of mucous membrane extending either backward to the arytenoid cartilages, as the *aryteno-epiglottic* (ary-epiglottic) folds, or laterally to the walls of the pharynx, as the *pharyngo-epiglottic* folds, which are often continuous with the *palato pharyngeal folds*. Between the free portion of the epiglottis and the base of the tongue are three folds of mucous membrane, two *lateral* and one *median*. The *median* fold (epiglottido glossal frenum) is the stoutest of the three, and contains, according to Cruveilhier, some elastic tissue.

The posterior surface of the epiglottis, when the mucous membrane is removed therefrom, is found to be marked by numerous pits for the reception of mucous glands.

Remarks.—The clinical remarks on the cartilages of the larynx are naturally grouped under the heads of the cartilages themselves.

The cricoid cartilage.—The posterior (pharyngeal) surface of the cricoid cartilage is often the seat of diseased action, inducing pharyngeal spasm and dysphagia.[1] Necrosis, with subsequent inflammatory involvement of the œsophagus, is a recognizable lesion of the cartilage, the sequestrum at times effecting an exit into the pharynx or œsophagus.

The cartilage corresponds to the bodies of the fifth and sixth cervical vertebræ.

[1] W. Gibbs, Trans. Path. Soc. London, 1866, 39.

A transverse line drawn from the cricoid cartilage across the neck would pass over the spot where the Omo-Hyoid muscle crosses the common carotid artery.

The region of the cricoid cartilage is that to which abnormal sensations of the pharynx are often referred. This is doubtless owing to the fact that in irritated states of the pharynx the act of deglutition is painful, and since the cricoid lies at the lower part of the pharynx its motions determine a greater amount of distress than do corresponding motions at any other portion of the throat.—Firm, gentle pressure backward against the cricoid develops pain in laryngeal phthisis, and in the incipient stage of carcinoma of the œsophagus when this disease is located at the upper portion.—The cartilage is relatively more prominent in women than in men, and is often the site to which abnormal sensations are referred by neurotic subjects.

The Arytenoid Cartilages.—The arytenoids are subject to necrosis and to tubercular inflammation.—The mucous membrane over the cartilages is often acutely inflamed in pharyngitis.

The Thyroid Cartilage.—Manipulation of this cartilage is a valuable aid in diagnosis of morbid conditions of the neck; thus, pushing the cartilage downward causes pain in pharyngitis. The cartilage is carried forward in post-pharyngeal abscess.—The thyroid cartilage is more or less translucent, and permits light to be transmitted in the living subject from side to side.[1]

A peculiar friction sound is heard by moving the larynx laterally, which is caused by the posterior border of the thyroid cartilage and the posterior surface of the cricoid cartilage moving together with the lower part of the pharynx against the vertebral column. Care should be taken to distinguish between such normal crepitus and that accompanying fracture of the thyroid cartilage. The normal crepitus disappears in retro-pharyngeal abscess, but persists in retro-laryngeal abscess.

In studying cases of suspected fracture of the thyroid cartilage it is important to remember that the upper horn is sometimes found separate from the body.[2]

[1] Czermak, Kehlkopfspiegel, Leipzig, 1860, 21.

[2] Luschka, Virchow's Archiv, 1868, 478.

Adam's apple may be concealed by œdema and deflected from its position in the median line in post-pharyngeal abscess.

The notch at the upper border of the thyroid cartilage does not appear until puberty.

The Epiglottis. (Fig. 7, Plate XCIX., fig. 5, Plate CIII., Plate CIV.) The shape of the epiglottis appears to be in a measure determined by the condition of the muscles of the pharynx. The cartilage, when narrow, pointed, and deflected backward, is often found associated with a powerful yet fretted pharynx, or at least with one in which a history of pharyngeal distress can be elicited. The cartilage when broad and shallow is often associated with a capacious, tractable pharynx.—The lateral borders of the cartilage may touch the sides of the pharynx either from an unusual increase of the diameters of the cartilage or from thickening or relaxation of the pharynx.

In self-inflicted transverse wounds of the neck (the upper border of the thyroid cartilage being taken as a guide) the epiglottis is divided.—The epiglottis is peculiarly liable to sloughing from tubercular and syphilitic disease.

The epiglottis is an accessory to the closure of the glottis, and also aids in directing the mucus expelled from the trachea into the mouth. The mechanism of passive closure of the glottis as contrasted with active or muscular closure by the constrictor muscles is as follows: the base of the tongue in deglutition presses downward upon the upper surface of the epiglottis while the larynx is raised, and the glottis thereby lies against the under surface. The epiglottis is thus not altered in position, being held between the tongue and the larynx.—It is agreed by observers that the glottis can be closed without the aid of the epiglottis, so that, when this structure is malformed, congenitally absent, or has been lost by disease or injury, deglutition is not necessarily impaired. Larrey,[1] it is true, mentions two cases of gunshot wound involving the loss of the epiglottis, in which dysphagia followed, in one case indeed persisting after cicatrization; and A. Flint, Jr.,[2] describes a case of syphilitic sloughing of the epiglottis in which cough-

[1] Mémoires, i. 313.

[2] Physiology, ii. 200.

EXPLANATION OF PLATE CIII.

Fig. 1. The hyoid bone and the larynx, with ligaments seen from in front.

Fig. 2. The same, seen from the side.

Fig. 3. The hyoid bone, seen from in front.

Fig. 4. The same, seen from above.

Fig. 5. The larynx in position, seen from behind.

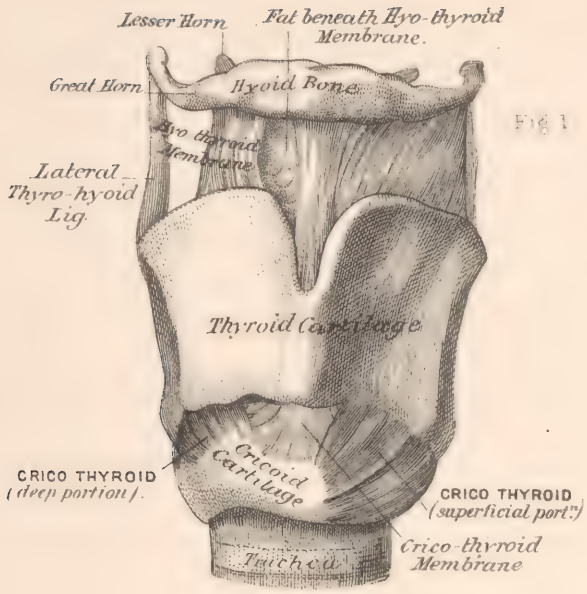


Fig 1

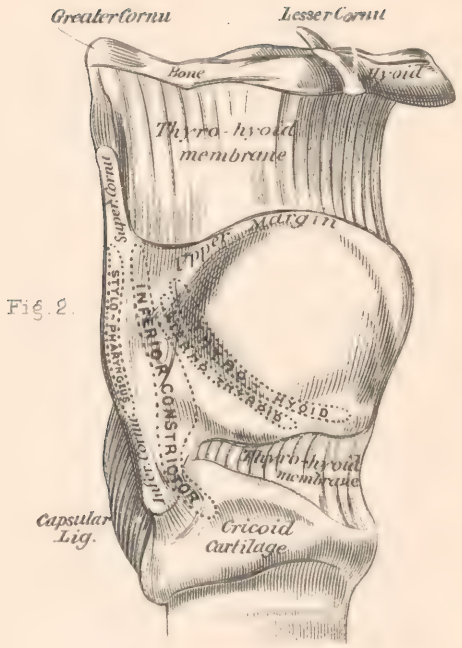


Fig. 2

Fig 3

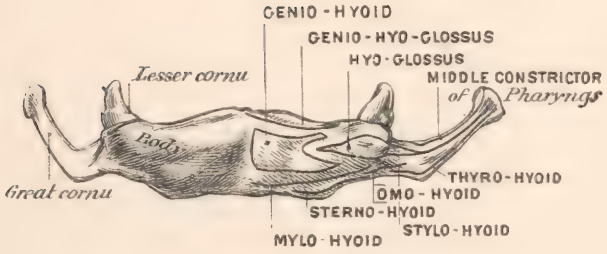


Fig. 4

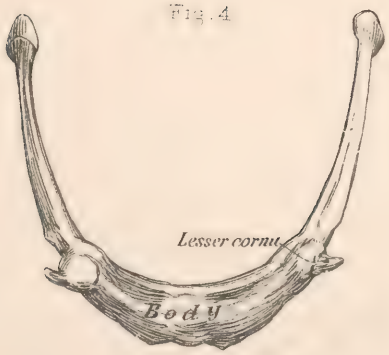
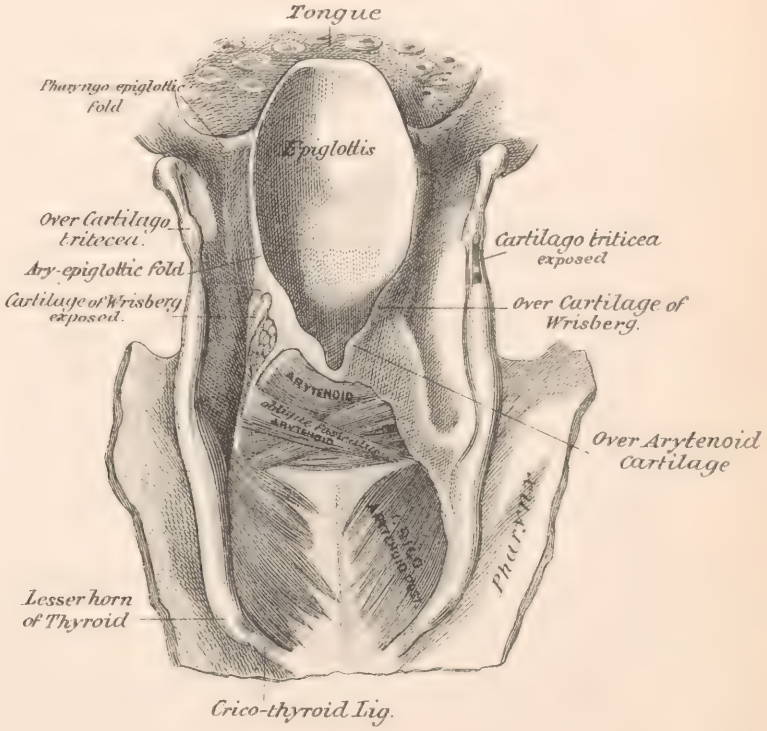


Fig 5.



T. Sinclair & Son, Lith.

ing and general distress always accompanied the act of swallowing while the patient was in the erect position. But it is probable that in both these cases the muscular fibres of the glottis may have become incompetent, either through destruction of their nerves, or by inflammatory infiltration and degeneration.

The base of the epiglottis lies deeply seated behind the hyoid bone, and, strictly speaking, cannot be necrosed or excised. When the epiglottis is mentioned in connection with clinical reports it is accepted that the free portion as seen without dissection is intended. The clinical relations of the deeper structures are chiefly to be studied in connection with the region of the hyoid bone rather than with the region of the larynx.—The resisting fibro-adipose tissue which lies between the hyoid bone and the base of the epiglottis may be the site of a bursa which may become sufficiently large to be brought to the attention of the surgeon.—The bursa over the hyoid bone may communicate with the deeper bursa. The tendency to laryngitis after removal of the hyoidean bursa has been repeatedly observed.

The Ligaments of the Larynx.

The Ligaments of the Larynx (Plate CIII.) are—

The Thyro-Hyoid Ligament.
The Crico-Tracheal Ligament.
The Crico-Thyroid Ligaments.
The Crico-Arytenoid Ligament.
The Hyo-Epiglottic Ligament.
The Thyro-Epiglottic Ligament.

The Thyro-Hyoid Ligament is composed of three parts, a median and two lateral.

The *median ligament* extends between the whole of the upper border of the thyroid cartilage and the upper posterior border of the hyoid bone. It does not, therefore, simply occupy the space between the two structures named, but guides the body of the hyoid bone a little obliquely downward and forward. The membrane is thicker in the middle than at the sides.

A well-defined bursa (infra-hyoid bursa) is intimately connected with the membrane. It ascends to occupy the space between the membrane and the posterior border of the hyoid bone. A second bursa is occasionally seen between the great horn of the hyoid bone and the posterior border of the thyro-hyoid ligament. The membrane is perforated on each side by the superior laryngeal artery and nerve.

The *lateral ligaments* are two in number, one for each side. Each is a short rounded yellow cord which connects the end of the great cornu of the hyoid bone to the superior cornu of the thyroid cartilage. Each contains ordinarily a nodule of cartilage (cartilago triticea).

The Crico-Tracheal Ligament is a fibrous structure which unites the lower border of the cricoid cartilage with the first tracheal ring. This border is infrequently continuous with the first ring either on the one side or on both.

The Crico-Thyroid Ligaments (crico-thyroid membrane). These are three in number, a median and two lateral.

The *median ligament* is of the shape of a truncated cone, its base being attached to the cricoid cartilage at its upper border, and its apex to the lower border of the thyroid, and also to the vocal membrane within. It is stout and slightly convex in front, and is composed of yellow elastic tissue. It is pierced by one or more openings for the entrance of minute arteries and veins, which supply the laryngeal mucous membrane. It may, however, simply be crossed by an anastomotic arch derived from branches of the right and left superior thyroid arteries.

Each *lateral ligament* presents a stout slip which extends from the cricoid cartilage upward and inward, and an anterior slip which passes upward and outward.

These slips serve to protect a *capsular ligament* lodged between the cricoid and thyroid cartilages.

The Crico-Arytenoid Ligament. Anterior and posterior slips are present, of which the posterior is the stouter. The *capsule* of the crico-arytenoid joint is loose to allow extended motion of the arytenoid upon the cricoid cartilage. Luschka places the facets of this joint among the screw-like articular surfaces.

The Hyo-Epiglottic Ligament. This extends from the hyoid bone upward and backward to the epiglottis.

The Thyro-Epiglottic Ligament extends between the thyroid cartilage and the front of the epiglottis. The space between the two ligaments last named and the epiglottis is occupied by a quantity of fat and fibrous tissue, and by a few glands. In addition to the ligament uniting the thyroid cartilage and epiglottis, a second band is seen uniting the base of the epiglottis to the re-entering angle of the thyroid cartilage.

The vocal membrane.—Between the re-entering angle of the thyroid cartilage and the vocal process of each arytenoid, extends the *Inferior Thyro-Arytenoid* ligament, which, when covered with mucous membrane, constitutes the *true vocal cord* of the laryngeal

image. Extending laterally from this ligament, and downward to the superior border of the cricoid cartilage, is the *vocal membrane*, which is continuous in front with the median portion of the crico-thyroid ligament. The upper border of this membrane, with the vocal cord to which it is attached, forms the lower boundary of the *laryngeal pouch*.

Stretching along the upper border of the laryngeal pouch is a membrane, known as the *superior thyro-arytenoid ligament* or the *false vocal cord* of the laryngeal image.

In addition to these structures the larynx exhibits several elevations of the mucous membrane which have received the name of ligaments, without, however, strictly deserving this name. These are formed by prominences of pharyngeal fascia covered with mucous membrane. The most important fold of this description, pertaining to the interior of the larynx, is the ary-epiglottic. The ary-epiglottic ligament forms the lateral border of the aperture of the larynx, and extends between the tip of the arytenoid eminence and the side of the epiglottis. It contains the cartilage of Wrisberg, and along its free border is the seat of a number of mucous glands. It is continuous at its base with the eminence of the false vocal cord.

Tourtual and Luschka have described the membranous lining of the larynx as a continuous structure—the lower part terminating at the true vocal cord; the middle part lining the laryngeal pouch, and ending in the false vocal cord; the upper part forming a quadrangular membrane, which terminates at the ary-epiglottic fold.

REMARKS.—The thyro hyoid ligament may be ruptured, as occurred in a case of J. H. Stallard.[1] A man, aged forty-four, suffering from phthisis, with laryngeal irritation, "felt something give way during a paroxysm of coughing. On examination, the right greater cornu of the hyoid bone was felt to be loose beneath the integument. It was separated by at least an inch and a half from the thyroid cartilage. During deglutition the hyoid bone was drawn upward, and the larynx tilted downward at the posterior part, thus increasing the distance between the thyroid cartilage and the hyoid bone, the connection being maintained in front only by the thyro-hyoid membrane."

A small lymphatic gland lies upon the thyro-hyoid membrane beneath the Thyro-Hyoid muscle. Enlargement of this gland may induce dysphagia and dyspnœa. Occasionally it is the seat of encephaloid cancer. A case of the latter mentioned by A. Burns[1] was remarkable for extending inward and upward along the pharyngeal wall.

Thyro-hyoid abscess has its seat in a mass of cellular tissue occupying a space behind the thyro-hyoid membrane, close to the base of the epiglottis. The suppurative inflammation of this part of the throat may be idiopathic, or may be symptomatic of an affection of the tongue, of the epiglottis, or of the thyroid cartilage. It may create œdema in the sub-epiglottic connective tissue, and in that of the ary-epiglottic ligaments, besides forcing the epiglottis upon the laryngeal aperture. The abscess extends toward the mouth, and its projection can sometimes be felt in the fossa between the base of the tongue and the epiglottis.

THE MUSCLES OF THE LARYNX.

The Muscles of the Larynx (Plates CIII., CIV.) are—

The Crico-Thyroid.
The Posterior Crico-Arytenoid.
The Lateral Crico-Arytenoid.
The Arytenoid.
The Thyro-Arytenoid.
The Thyro-Epiglottideus.
The Aryteno-Epiglottideus.

[1] Trans. Path. Soc. Lond., 1860, xi. 36.

[1] Surg. Anat. of Neck, 118.

EXPLANATION OF PLATE CIV.

Fig. 1. The larynx opened from behind; the left side with structures dissected from the interior aspect; the right side is displayed in sinistro-dextral transverse (frontal) section.

Fig. 2. The larynx, trachea, and bronchial tubes in position, seen from in front.

Fig. 3. The larynx, so displayed as to give a view of the intrinsic muscles, after the removal of one side of the thyroid cartilage.

Fig. 4. The laryngeal image, seen by reflected light, showing the vocal cords abducted.

Fig. 5. The same, showing the vocal cords adducted.

Fig. 6. The cricoid cartilage, the arytenoid cartilage, and the cartilages of Santorini. The structures last mentioned have been named *cornicula laryngis*.

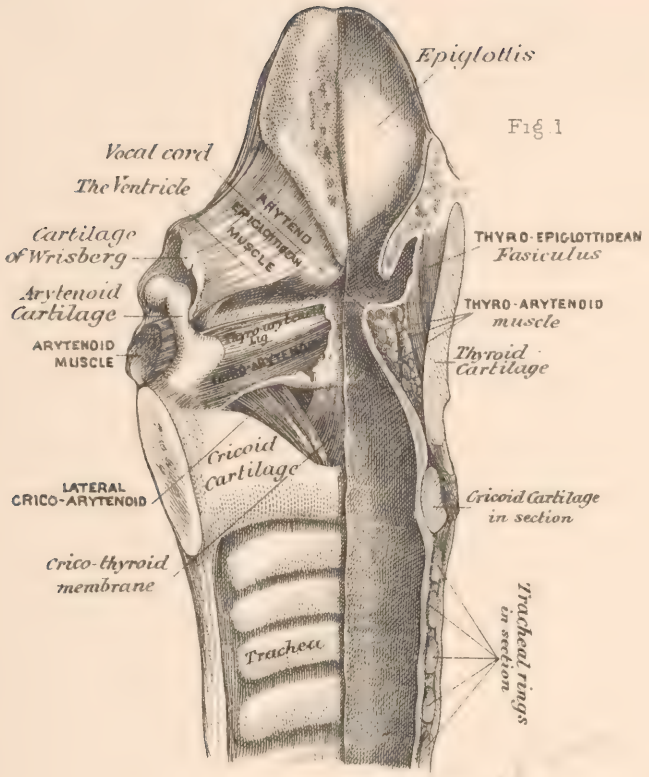


Fig 1

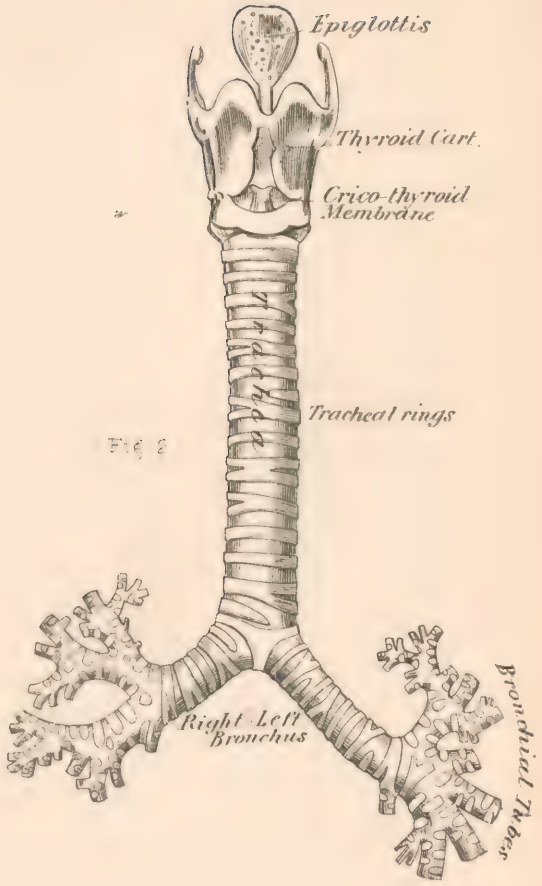


Fig 2

Fig. 4.

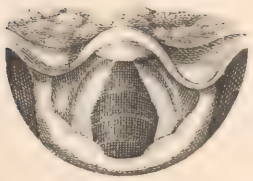


Fig. 3.

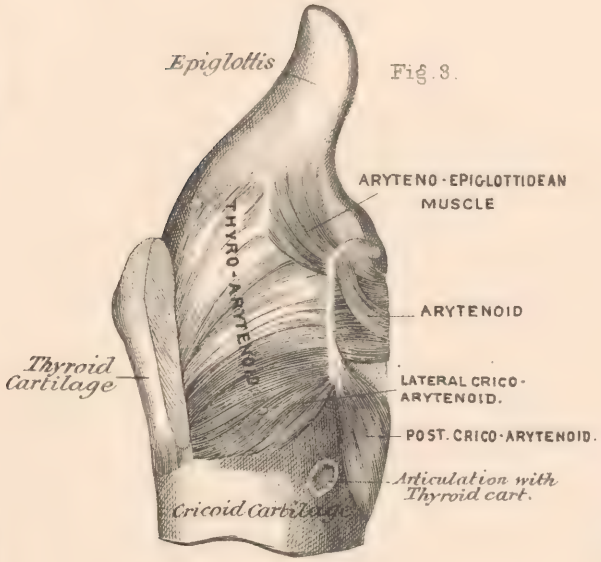
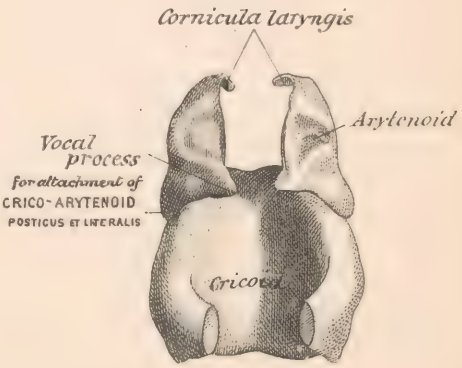


Fig 5.



Fig 6



T. Sinclair & Son, Lith.

The Crico-Thyroid is a short triangular muscle which arises from the side of the cricoid cartilage. Its diverging fibres pass upward and outward, and are inserted into the thyroid cartilage, from the base of the lower cornu forward to near the median line.

Action.—The Crico-Thyroid has a fixed point of origin in the cricoid. It draws the thyroid cartilage down toward this origin, and thus makes tense the vocal cord indirectly. The motion of the thyroid cartilage while downward is also somewhat rotatory forward.[1]

Some of the more superficial fibres of this muscle may be traced into the Inferior Constrictor. The lower fasciculus is composed of nearly horizontal fibres, and is sometimes distinct. A triangular space is left between the anterior border of the Crico-Thyroid muscles, thus exposing the crico-thyroid membrane. An inconstant slip extends from the cricoid cartilage to the lower end of the inferior cornu of the thyroid cartilage, forming the Kerato-Cricoid muscle.

The Posterior Crico-Arytenoid muscle arises from the entire lateral half of the posterior surface of the cricoid cartilage. The muscle is in consequence broad and somewhat quadrangular. Its fibres pass upward and outward, and are inserted into the outer part of the musculo-articular process of the arytenoid cartilage.

Action.—To abduct and rotate the arytenoid cartilage, and in consequence to abduct the vocal cord.

The Lateral Crico-Arytenoid muscle arises from the upper margin of the side of the cricoid cartilage. It is a small slip compared with the Posterior Crico-Arytenoid, and is apt to be continuous at its upper margin with the Thyro-Arytenoid. Passing upward and backward, it is inserted into the musculo-articular process of the arytenoid cartilage in front of the insertion of the preceding muscle.

Action.—To adduct the arytenoid cartilages, and in consequence the vocal cord.

The muscle is concealed from without by the thyroid cartilage; and upon its anterior part it is covered by the upper part of the Crico-Thyroid muscle.

The Arytenoid is a single muscle, although occupying the posterior surfaces of both arytenoid cartilages. It is composed of two sets of fibres, a deep circular, the shorter of the two, often spoken of as the *true arytenoid*, and a superficial oblique set, divided into two parts, which cross each other at an oblique angle. The latter are continuous anteriorly with the outer layer of the Thyro-Arytenoid muscle, or with fasciculi of the Thyro Epiglottideus muscle.

Action.—To bring closely into apposition the arytenoid cartilages and aid in adducting the vocal cords.

Merkel has described a *filtrum ventriculi* by means of which the laryngeal pouch empties its secretion into the pharynx.

The Thyro-Arytenoid muscle (vocal muscle) arises from the lower part of the re-entering angle of the thyroid cartilage, and passes as a broad thin ribbon of straight muscular fibres horizontally across the side of the anterior portion of the larynx, just beneath the vocal cord, to be inserted into the vocal process of the arytenoid cartilage.

Action.—To draw the arytenoid cartilage forward and thus relax the vocal cord, and to give tonicity to the vocal cord itself.

This muscle is of great complexity, and presents a range of variation perhaps unequalled among the muscles of the body. Its general plan may be said to present an *internal* and an *external* fasciculation, of which the internal preserves an intimate relation to the vocal membrane, and, what is especially noticeable, controls the free border of this membrane at the laryngeal pouch. It is inserted at the fovea oblonga and the vocal process of the arytenoid cartilage. The external portion, at first intimately associated with the internal, is, on the whole, less compact, and sends delicate bundles upward toward the outer wall of the laryngeal pouch to the inner border of the arytenoid cartilage.

Luschka describes, after Santorini, a distinct fasciculus which, while receiving the name of the Thyro-Arytenoideus Superior, is in many respects distinct from the above. It arises from the base of the notch of the thyroid cartilage at the posterior margin, and is inserted into the musculo-articular process of the arytenoid cartilage, or may send slips downward to the cricoid cartilage or the crico-thyroid membrane.

Still other fasciculi, which constitute the Thyro-Arytenoid-Epiglottic muscle, pass between the points named as a thin layer of inconstant fibres. They aid in forming the *oblique portion* of the Thyro-Arytenoid muscle.

The Thyro-Epiglottideus muscle is an irregular delicate fasciculus which arises from the re-entering angle of the thyroid cartilage to the outer side of the Thyro-Arytenoid, and ascends to be inserted upon the sides of the epiglottis.

Action.—To depress the epiglottis and assist in closing the superior aperture of the larynx.

The Aryteno-Epiglottideus muscle is upon the same plane as that of the preceding. It arises from the arytenoid cartilage, and is inserted upon the epiglottis.

[1] It was formerly supposed that the cricoid cartilage muscle was moved upward instead of the thyroid cartilage being moved downward. The expression in the text is based upon the researches of F. H. Hooper, Trans. Am. Laryngolog. Ass'n., 1883, 118.

The lower division of these fibres has been named by Hilton the Compressor Sacculi Laryngis.

Slips from both the muscles last named accompany and are continuous with the superficial interwoven fibres of the Arytenoid muscle. Both are continuous with each other, and constitute the Thyro-Aryteno-Epiglottideus muscle of Henle.

Remarks.—Acquaintance with the muscles of the larynx is essential to the correct interpretation of alterations of voice as dependent upon disease. Thus, the paralysis of the *adductors* of the vocal cords (the Lateral Crico-Arytenoid and the Arytenoid) causes abduction of the cords. Occasionally the Lateral Crico-Arytenoid of one side only may be the seat of degenerative change. Spasm of the adductors is the essential phenomenon of laryngismus stridulus.

Paralysis of the *abductors* of the vocal cords (the Posterior Crico-Arytenoid muscles) causes adduction of the cords. When bilateral it creates a condition dangerous to life by reason of the resultant complete adduction of the cords. M. Mackenzie[1] narrates two instances of involvement of the recurrent laryngeal nerve and consequent paralysis and degeneration of the above muscles. In one of these the patient was a male fifty years of age. An extensive cancerous growth had incorporated itself with the left recurrent nerve at a point at which it passes beneath the arch of the aorta. In the other instance,[2] that of a female aged twenty-six, a number of small and apparently benign tumors had developed near the trachea. One of these involved the left recurrent nerve in such a manner that the nerve appeared to be completely imbedded in the growth.

The *tensors* of the vocal cords—the Crico-Thyroids, as well as the *laxators* of the vocal cords, the Thyro-Arytenoids, may be all or severally diseased. Paralysis of the Thyro-Epiglottideus muscle may ensue upon diphtheria and progressive bulbar paralysis.—In the event of impairment of the function of the Thyro-Arytenoid muscle the condition is usually followed by an abnormally high pitched voice. This result may also ensue upon defective development of the muscle. The loss of voice, so frequently noticed in neurotic females, is usually due to paresis of this muscle.

THE INTERIOR OF THE LARYNX.

The Interior of the Larynx (figs. 1, 4, 5, Plate CIV.) is covered throughout with mucous membrane, which in some measure conceals the plan of the cartilaginous framework. It is divided at the position of the true vocal cords into two portions or regions, the *supra-glottic* and the *infra-glottic*.

The *supra-glottic* portion, which extends from the tip of the epiglottis to the true vocal cords, is wide, of a varied outline, more movable, and is furnished with a thicker mucous membrane, as compared with the infra-glottic portion; this portion presents a nearly circular outline, is almost immobile, and its mucous membrane is everywhere smooth, thin, and adherent. The diameter of both regions abruptly narrows at the glottis, so that the interior of the larynx can be happily compared to an hour-glass. This resemblance is best seen in a right and left vertical section of the adult larynx.

The supra-glottic portion presents for examination the pharyngo-laryngeal sinus and the vestibule of the larnyx.

The Pharyngo-Laryngeal Sinus (pyramidal sinus) is a relatively unimportant space between the inner wall of the thyroid cartilage and the outer wall of the vestibule as defined by the quadrangular membrane, and by the thyro-hyoid membrane and hyoid bone above. It has no connection with phonation, and is lined with mucous membrane having characteristics in common with that of the pharynx. It is often the seat of inflammation or of ulceration, and affords lodgment for foreign bodies.

The Vestibule of the Larynx is bounded above by the superior laryngeal aperture, below by the rima glottidis, and on the sides by the quadrangular membrane, the ventricle, and the false vocal cord.

It will be described as the interior is approached from above downward.

The Superior Laryngeal Aperture is of a triangular or cordiform figure, the apex of which is forward and the base backward. It is oblique from before backward and from above downward. In front is the epiglottis, from the side of which extend the aryteno-epiglottic folds; these terminate at the eminences of the cartilages of Santorini. To the outer side of the latter are seen the eminences for the cartilages of Wrisberg. At the median line of the posterior border is a deep vertical notch, the *inter-arytenoid space*, which is limited below by the cricoid cartilage and at the sides by the inner borders of the arytenoid cartilages.

The Arytenoid Glands. Along the aryteno-epiglottic border posteriorly are a number of racemose glands, which surround the eminences of the cartilages of Wrisberg. At the inner margin of the arytenoid cartilage they descend abruptly into the vesti-

[1] Lond. Hosp. Rep., 1867, 107.

[2] Trans. Path. Soc. London, 1868, 84.

bule, to form a ridge-like eminence of mucous membrane from the superior laryngeal aperture to near the ventricle. They may thus be described as having a horizontal and a vertical arrangement. Between this ridge and the anterior border of the arytenoid cartilage is a groove, called the *filtrum ventriculi* by Meckel, who supposed it to aid in the conduction of mucus from the ventricle to the pharynx.

The Quadrangular Membrane.—The side of the vestibule, which extends between the aryteno-epiglottic fold and the false vocal cord, has received from Tourtual the name of the quadrangular membrane.

The so-called False Vocal Cord (ventricular band) is a ridge-like eminence of mucous membrane extending from before backward across the side of the vestibule, and lying between the quadrangular membrane above and the ventricle below. It is covered with thin mucous membrane which is firmly adherent to the superior thyro-arytenoid ligament. The false vocal cord has no important function as far as is known. From its extreme sensitiveness it has been supposed by Luschka to serve as a monitor to the true vocal cord. The two bands may be approximated by the constrictor-like fibres of the Thyro-Arytenoid muscles.

The Ventricle of the Larynx (ventricle of Morgagni, laryngeal pouch). Between the true and false vocal cords is the elliptical orifice (rima) of the ventricle of the larynx. The *upper border* of the ventricle is somewhat curved upward; the lower is straight. The ventricle is narrow at the orifice, but is prolonged upward for about six lines in the space between the quadrangular membrane and the inner surface of the thyroid cartilage. As it ascends it curves slightly backward. This ascending portion is often spoken of as the *sacculi laryngis* (sac of Hlton), although this name is also applied to the ventricle. It may reach the upper border of the thyroid cartilage, and even pass beyond it. Luschka has recorded an example in which the top of the sac lay beneath the mucous membrane of the tongue. The ventricle receives the secretions from sixty or seventy small racemose glands, which are imbedded in the submucous and delicate fat tissue surrounding the sac. They are here surrounded by a membrane which is continuous with the false vocal cords. The glands are the occasional seat of cysts of retention. Bruns has described a case of this kind in which the tumor protruded into the cavity of the vestibule through the orifice of the larynx. Luschka found in one case a cyst of the size of a walnut, which lay beneath the Thyro-Hyoid muscle, and had apparently escaped detection during life.

The anterior border of the vestibule is formed by the *cushion of the epiglottis* and part of the *fovea centralis*. The cushion is composed of glands and a quantity of fat.

The *fovea centralis* is a small groove upon the anterior surface of the larynx at the re-entering angle of the thyroid cartilage. Its existence is determined by the want of absolute approximation of the true and false vocal cords.

The Glottis.—The glottis is that part of the larynx in which the true vocal cords are situated. It lies between the re-entering angle of the thyroid cartilage and the bases of the arytenoids, and resembles a narrow triangle in shape, having its base posteriorly. It is bounded in front by the fovea centralis, at the side by the vocal cords and vocal processes, forming the lips of the glottis, and behind by the inter-arytenoid notch. The opening between the cords is called the *chink of the glottis* (rima glottidis). It is eleven lines long in the male, and nine in the female, with a width, in easy respiration, of three or four lines. Each vocal cord is prismatic, having its base outward. Its upper border is horizontal; its lower extends obliquely downward and outward. Much of its bulk is due to the presence of the Thyro-Arytenoid muscle beneath the mucous membrane.

Luschka speaks of that portion of the chink between the vocal cords as the *inter-ligamentous rima*, and of that between the vocal processes as the *inter-cartilaginous rima*.

The *mucous membrane of the larynx* is loose on the anterior surface and the free border of the epiglottis, but firmly adherent and smooth on the posterior surface. It is also loose on the posterior surface of the arytenoids; on the aryteno-epiglottic folds to permit free motion of the arytenoid cartilages; as well as in the laryngo-pharyngeal sinus, and within the laryngeal pouch. It is adherent to adjacent structures at the quadrangular membrane, also at the true and false vocal cords and in all of the infra-glottic region.

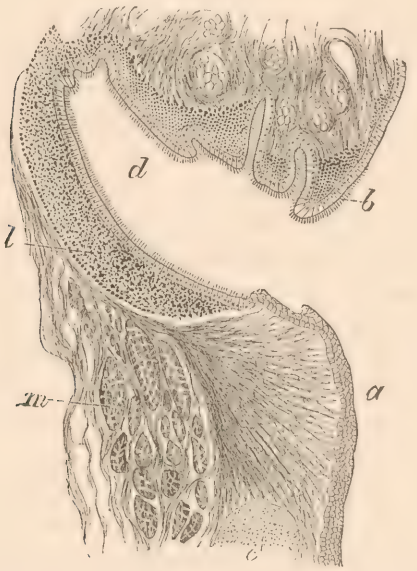
In consequence of the arrangement above described, œdematous conditions are common on the anterior surface of the epiglottis, and round the superior aperture of the larynx, while they are rare elsewhere.

The *epithelium* is of the ciliated variety except where it lines the inter-arytenoid space and thence to the glottis where it is squamous.

The mucous membrane varies in color from a delicate yellowish-pink on the margin of the epiglottis,

to a deep pink or light red at its base down into the vestibule. The false vocal cords are of a light pink hue, while the true vocal cords are of a pearly or yellowish-white.

Fig. 186.



From a longitudinal section through the ventricle of the larynx of a child. *a*, True vocal cord; *b*, false vocal cord; *c*, a nodule of elastic cartilage; *d*, ventricle; *l*, lymphatic tissue; *m*, bundles of the Thyro-Arytenoid muscle in transverse section.

According to P. Coyen,[1] the vocal cord may contain a few minute racemose glands.

The Infra-Glottic Region of the larynx is a rounded space corresponding in shape nearly to the general outline of the cricoid cartilage, but somewhat modified at the side by the lower two of the crico-thyroid ligaments. Its junction with the trachea may be called the *inferior aperture of the larynx.* The mucous membrane is everywhere smooth and adherent, resembling in general appearance that of the larynx.

The Laryngeal Image.—At the risk of repeating in part the description of the larynx, the account of the laryngeal image will include the following: The laryngeal image is a foreshortened view of the parts included within the laryngeal aperture when seen reflected in the laryngeal mirror. Describing the component parts of the image from above downward, since the anterior border of the laryngeal aperture is also the upper border of the image, the first structures seen are the cervical free edge and the cushioning base of the *epiglottis.* The epiglottis may be curved forward, may be thickened and so inclined as partially, if not entirely, to obscure the parts lying below the plane of the aperture. At the sides of the aperture are seen the *aryteno-epiglottic folds*, together with the *eminences of the cartilages of Wrisbery and Santorini.* The latter surmounts the arytenoid cartilage, which moves coincidently with it. The *base of the arytenoid* itself may be determined to the median side of the cartilage of Santorini. Between the bases of the arytenoid cartilages is seen the *inter-arytenoid notch.* Lying within the aperture, but on a lower plane, extending across the angle formed by the junction of the contour of the epiglottis with that of the aryteno-epiglottic fold, is the *false vocal cord.* Lying to the median side of the pinkish false vocal cord is seen the *true vocal cord*, which extends across the plane of the laryngeal aperture in a nearly straight line.

The inferior third of the true vocal cord represents the vocal process of the arytenoid cartilage; it is of a yellow or white color, and is rigid in form. The superior two-thirds represents the position of the Thyro-Arytenoid muscle and the mucous membrane over it. It is of a delicate pearl tint, and is vibratile in many of the acts of speech.

The chink lying between the false and the true vocal cords corresponds to the position of the orifice of the *ventricle*, while the space between the true vocal cords is recognized as the *glottis.* In favorable subjects a few tracheal rings, and even the orifices of the place of division of the bronchial tubes, also can be seen.

The relations between the several parts of the image undergo changes in respiration and in speech. The most striking of these consist of the widening or narrowing of the inter-arytenoid space and of the glottis. When the inter-arytenoid space is widened the baggy mucous membrane over the arytenoid eminence and the cartilages of Santorini are seen lying as a broad smooth ellipse against the posterior wall of the pharynx; when the space is narrowed the mucous membrane is somewhat corrugated, and to a slight degree removed from contact with the pharynx. When the glottis is widened the tracheal rings may be seen through a wide, nearly lozenge-shaped space, each border of the true vocal cord being slightly angulated at the point where the vocal process of the arytenoid cartilage is defined.

When the glottis is narrowed the shape of the interspace between the cords varies according to the relative disposition of the vocal processes and of the vibratile portion of the true vocal cords. These are subject to contrasts, as the parts are disposed to emit

[1] Archiv. de Physiologie norm. et pathol., 1874, 92. Pl. vi.

certain sounds either for speech, or for the creation of musical tone, and need not be analyzed in this place.

Œdema of the larynx differs in its physical features whether it be above or below the glottis. The differences in the mucous surfaces already mentioned are of great influence in the localization of this disease. As defined by clinical writers the *supra-glottic œdema* is the more frequent of the two forms. The swelling is pronounced, ordinarily involves the false vocal cords, and is accompanied by submucous infiltration. It has sometimes been described as hanging down like a bag, so as completely to fill the chink of the glottis. *Infra-glottic œdema*, a rarer affection, is accompanied by relatively little swelling, owing to the more intimate association here existing between the mucous membrane and the cricoid cartilage. Annular masses of mucus may be formed in this condition of the larynx.—Moxon[1] describes an eversion of the lining of the ventricle of the larynx. At first sight it appeared to be a tumor hanging down over one of the vocal cords, semi-elliptical in shape, and attached above in the anterior half of the ventricle of the larynx. On examination it was found that the everted portion could easily be put up into the usual position of the sacculus of the larynx, and when so placed it appeared as the sacculus laryngis.

Hyrtl[2] describes a delicate fold extending from the epiglottis to the hyoid bone.

Bloodvessels.—The larynx is supplied with branches of the superior and inferior thyroid *arteries*. The mucous membrane is supplied by the superior and inferior laryngeal arteries. The Crico-Thyroid, the Aryteno-Epiglottideus, and the Thyro-Epiglottideus are supplied by the superior laryngeal, the first-named by a separate branch which is called by some writers the crico-thyroid branch. The Thyro-Arytænoidei, the Crico-Arytænoidei, and the Arytænoidei are supplied by both the superior laryngeal and the inferior laryngeal arteries.

The *veins* of the mucous membrane and of the muscles of the larynx are tributary to the superior thyroid and inferior thyroid veins, and thence to the internal jugular.

Nerves.—The nerves of the larynx are derived from the pneumogastric. The mucous membrane and the Crico-Thyroid muscles are supplied by the superior laryngeal nerve, and the remaining muscles by the inferior laryngeal.

[1] Trans. Path. Soc. Lond., 1868, 65. See, also, G. M. Lefferts, Am. Journ. Med. Sci., 1878.

[2] Sitzungsberichte, Wien. Acad. xxv.

Lymphatics.—The lymphatic tissue of the larynx is abundant (Fig. 186). The lymphatic vessels pass to the deep lymphatic glands of the neck.

THE TRACHEA.

The Trachea (fig. 2, Plate CIV., Plate CV., Plate CVI.) is that portion of the respiratory tract which is placed between the larynx and the bronchi.

The trachea is a nearly cylindrical tube broader below than above, and composed of from sixteen to twenty C-shaped cartilages which are separated by narrow intervening spaces. The cartilages define the trachea in front and at the sides; behind, the tube is formed by a flat yielding membrane which unites the ends of the cartilages.

The trachea measures from four to four-and-a-half inches in length, three-fourths to one inch in width. It is somewhat more capacious in the male than in the female.

Relations.—The trachea extends from the fifth cervical vertebra to the third or the fourth or even to the fifth dorsal vertebra. The upper two-thirds of the tube lie in the region of the neck, and the lower third in the thorax. While lying in the middle line of the neck and of the trunk the trachea is freely movable from side to side. The trachea is closely invested in a delicate but resisting fascia (fascia laryngo-trachealis, fascia thyro-trachealis). The relations are consecutively grouped as follows: the cervical and the thoracic. The *cervical relations.* In front, covering the second, third, and fourth rings, lie the isthmus of the thyroid body, the Sterno-Hyoid and Sterno-Thyroid muscles, the deep cervical fascia, some intercommunicating branches of the anterior jugular veins, the inferior thyroid vein, and occasionally the *arteria thyroidea ima.* Near the sternum the trachea is crossed by the innominate artery. At the sides lie the lobes of the thyroid body and the common carotid artery, the inferior thyroid artery, and the recurrent laryngeal nerve. Behind lies the œsophagus.—The *thoracic relations.* The trachea lies in the middle mediastinum between the pleuræ. In front lie the Sterno-Hyoid and Sterno-Thyroid muscles and the manubrium of the sternum. Behind, the trachea rests upon the œsophagus, though this tube inclines to pass to the left side. On the right side the trachea is nearer the pleura than toward the left, while on the left it is nearer the left carotid artery than is the right near the right carotid artery. The pneumogastric nerves lie on either side of the trachea.

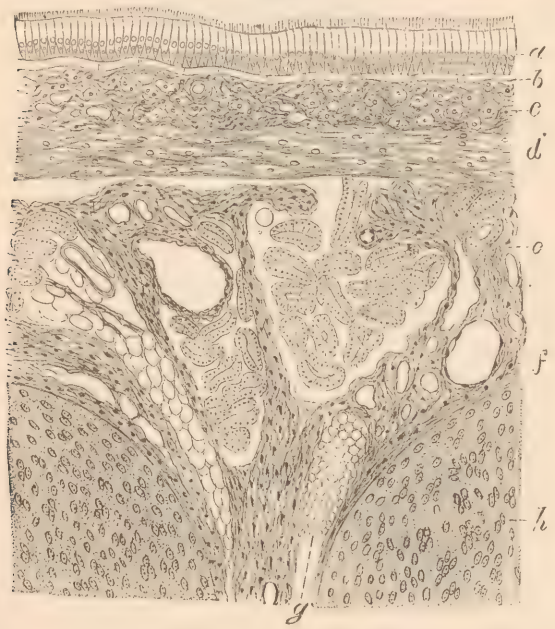
The trachea divides into the bronchi about opposite the spine of the fourth dorsal vertebra, and opposite the junction of the manubrium and gladiolus.

Structure.—The C-like cartilages are flat in front, and are more or less imbedded in fibrous tissue. They are convex behind, and are here conspicuous when seen from within the trachea. The first cartilage is often broader than the

others, and is apt to be united at the sides with the lower border of the cricoid cartilage. The lower border of each ring is often furnished with one or more irregular or simple processes. The last tracheal ring, which lies at the bifurcation of the bronchi, is of a triangular shape.

The posterior membranous portion of the trachea is composed of fibro-elastic and muscular tissue. The *fibrous layer* is continuous around the entire tube in front, and at the sides partially imbedding the tracheal rings. It is continuous above with the perichondrium of the cricoid cartilage. The elastic layer, composed of fibres which are arranged longitudinally, occupies the spaces between the rings, and is intimately connected with the mucous membrane. The mucous membrane is marked near the bifurcation of the bronchi by a few faintly developed longitudinal folds.

Fig. 187.



From a longitudinal section through the trachea of a child. *a*, The stratified columnar ciliated epithelium of the internal free surface; *b*, the basement membrane; *c*, the mucosa; *d*, the networks of longitudinal elastic fibres; the oval nuclei between them indicate connective-tissue corpuscles; *e*, the submucous tissue containing mucous glands; *f*, large bloodvessels; *g*, fat-cells; *h*, hyaline cartilage of the tracheal rings.

The muscular layer is thin, and composed of pale, unstriated fibres, which are confined for the most part to transverse bundles entering the incurved ends of the C-like cartilages. The muscle-layer is crossed by sparsely distributed longitudinal fasciculi. To the outer side of or incorporated with the layer are occasionally seen small nodules of cartilage called by Luschka the intercalar cartilages.

The *mucous membrane* is thin and of a yellowish-red color. It is firmly adherent by means of elastic fibres to the elastic coat, and is covered everywhere with ciliated epithelium.

The glands opening upon the trachea are of the racemose type, those upon the posterior wall of the tube being the best developed. Rokitansky has described retention cysts of these glands under the name of tracheocele.

Bloodvessels.—The *arteries* of the trachea in the *neck* are derived from the tracheal branches of the inferior thyroid arteries. The *veins* in the neck contribute to the inferior thyroid veins and thence to the innominate veins.

The *nerves* are derived from the recurrent branches of the pneumogastric nerve.

The *lymphatics* in the neck pass to the inferior deep lymphatic glands of the same region.

In the *thorax* the trachea receives twigs from the aorta; the nerves are derived from the pneumogastric, and the lymphatic vessels join the tracheal glands.

Variations. — The trachea has been found by Serres[1] duplicated in a specimen of hetoredelphia. It may end blindly a short distance below the cricoid cartilage or be at about the same level fused with œsophagus. For other defects see Œsophagus.

Remarks.—The trachea is peculiarly exposed to causes of compression, not only because of the position occupied by it in the neck, but because of the yielding character of the tracheal walls. Besides, its tract lies in regions which are liable to many grave morbid processes, among which may be mentioned goitre, sarcoma, aneurism of the great vessels, enlargements of lymphatic glands, and diseases of the clavicles, ribs, and sternum. It is thus liable to be deflected from the median line—a fact of importance to remember in the operation of tracheotomy in an adult having a cervical tumor. The trachea is also liable to intra-mural changes, chiefly of a fibroid character, which narrow its lumen and impede the ingress and the egress of air. The trachea is frequently invaded by disease originating in other structures. Thus a tuberculous abscess has been known to ulcerate through the tracheal walls and cause death by suffocation. Cancer is a frequent cause of tracheal involvement, either by extending forward from the œsophagus, or by pressure from cancerous cervical or thoracic lymphatic glands. Aneurism, particularly the intra-thoracic form, may give rise to hemorrhage into its lumen. The trachea may be compressed at the point of bifurcation by lymphatic glands and induce symptoms of suffocation. Abscess of the lymphatic glands in this position may open into the trachea or bronchial tubes. It yields not only to the slow processes of disease, but to injuries as well. In the thorax its position protects it from all injuries but penetrating wounds. In the neck it is otherwise, and, especially when the head is thrown backward, the trachea may be ruptured

[1] Mus. d'Hist. Nat. xv. 1827, 4.

by a blow, or the contusion of a carriage wheel. The trachea has been ruptured by the act of coughing.[1] A polyp of the trachea is described by W. C. B. Tifield[2] which acted like a ball-valve at the orifice of the left bronchus, permitting expiration but impeding inspiration.

Fracture of the larynx and rupture of the trachea are serious lesions. W. Hunt[3] found in studying the literature of twenty-seven cases that seventeen died. J. Atlee has reported a case of complete loss of continuity in the cervical portion of the trachea in a child, which resulted in death in a few moments.

THE BRONCHI.

The trachea terminates in two branches, the right and left bronchi (fig. 2, Plate CIV., Plate CV.). The right bronchus, composed of six or eight rings, is the larger, though the shorter of the two, and passes downward and outward on the level of the fourth dorsal vertebra. It divides into two (and sometimes three) branches, of which the upper and smaller passes to the upper lobe of the lung. The bronchi subdivide into smaller passages called bronchial tubes.

The left bronchus measures two inches in length, and is directed downward and outward at the level of the fifth dorsal vertebra. It is composed of from nine to twelve rings.

According to Sappey, the bronchi near their origin correspond in front to the second intercostal space.

Remarks.—Hyrtl has found that the right lung of the newly born infant is the first to be inflated.—Foreign bodies more frequently slip into the right than the left bronchus.—The lymphatic glands situated at the origin of the bronchi are capable, when enlarged, of compressing somewhat the tubes and diminishing their calibre.—The pericardium and the left auricle must be placed among the indirect clinical relations of the left bronchus from the circumstance that diseases of the pericardium and of the left auricle may compress this structure. W. T. Gairdner[4] has found numerous examples of bronchial obstruction followed by emphysema and pulmonary collapse.—For relations with Œsophagus see that structure.

Bloodvessels.—The *arteries* of the bronchial tubes are derived from the anterior bronchial branches of the internal mammary, and from the posterior bronchial arteries which arise from the aorta. The branches last named may arise from the third intercostal arteries. The *veins* pass to the innominate veins and to the azygos vein. The *nerves* are derived from the inferior tracheal pneumogastric nerve.

[1] Bredschneider, Casper's Wochenschr. 1842, 461.
[2] Boston Med. and Surg. Journ., 1861, Nov. 14.
[3] Am. Journ. Med. Sci., li., 1866, 378.
[4] Month. Journ. Med. Sci., Edinburgh, 1850, 122.

THE LUNGS.

The Lungs are the organs of respiration. They occupy the greater part of the thoracic space, and are composed of a right and a left lung. Each lung may be said to be moulded to the shape of its own pleural cavity, and may be compared to a curve whose apex is directed upward, and whose base is directed downward. Each lung is again convex posteriorly, anteriorly, and at the lateral side; but is nearly flat on the median side, and is concave inferiorly. The base is inclined slightly downward and backward, so that it reaches a point farther down behind and at the lateral side than in front. A transverse section of the lung at its apex is nearly circular, oval in form; at its lower portions it is palm-shaped, the narrow portion of the figure being directed forward and the base backward.

The lung is everywhere free except at the region at which it is held in connection with the bronchial tubes and the pulmonary bloodvessels. These structures, together with the bronchial arteries, veins, nerves, and lymphatics, form a narrow pedicle, which is known as the *root of the lung*. The lung may be said to hang by its pedicle, as a fruit by its stem. The pleural fold which covers the lung pedicle and aids it in supporting the lung has received the name of the *ligamentum latum pulmonis*. The right lung-pedicle lies in front of the azygos vein, the left beneath the aortic arch, and partly in front of the descending portion of the aorta.

The lung presents for examination—

The Anterior Border.
The Posterior Border.
The Median Surface.
The Lateral Surface.
The Base.
The Apex.

The *anterior border* is compressed and presents an uneven contour. Upon the left lung this border is intended at its lower part for the accommodation of the heart.

The *posterior border* of the lung is nearly twice the length of the anterior. It is broad and massive, and is accommodated within the pulmonary groove of the thorax. It lies between the median and lateral surfaces; from the former it is separated by a well-defined line.

The *inner surface* presents a slight concavity above and a deeper one below for the reception of the heart. Upon this surface a hilum is seen at which the bronchi, arteries, and nerves enter the lung, and the veins and lymphatics escape.

The *outer* surface is directly continuous with the *anterior*. The two form the largest superficial area of the lung surface corresponding to the sides of the thorax. In expiration the anterior portion of the outer surface recedes from the front of the chest.

The *base* (inferior surface) is of a semilunar shape. It is concave and rests upon the Diaphragm. The outer and posterior portion is produced as a thin edge in the narrow space between the Diaphragm, the ribs, and the intercostal spaces.

The *apex* is that portion of the lung situated above the impression for the heart. It has to its inner side the subclavian artery, the superior intercostal nerves, the inferior cervical ganglion of the sympathetic nerve, and finally the anterior branch of the eighth cervical nerve. It extends above the level of the first rib into the neck.

The right lung is broader and more capacious than the left. It is divided by a fissure which extends from about three inches below the summit, downward and forward, and forms the dividing line between the *upper* and the *lower* lobe. Near its anterior third the fissure bifurcates, the lower portion continuing downward and forward, the upper, upward and forward, thus creating a third lobe (middle lobe).

In front the base of the right lung answers in adults to the inferior border of the fifth rib; that of the left lung to the superior border of the sixth rib.

The left lung is distinguished by having but two lobes. In some instances the anterior margin forms a tongue-like lobule projecting forward, which, from the fact that it lies over the pericardium, is sometimes called the *cardiac tongue*. In both lungs the basal or lower lobe is the larger of the two.

The weight of the lung is two-and-a-half pounds. The left lung weighs fourteen and a half ounces, and the right fifteen and a third. Its specific gravity is from 3.45 to .746.

Sometimes a cyst-like effect is produced by the partial agglutination of the sides of a portion of the fissure separating the lobes.

Relations.—The root of the lung extends vertically from the superior border of the cartilage of the second rib to the inferior border of the cartilage of the third, and in a transverse direction from the borders of the sternum to about an inch beyond.—The relations of the parts within the pedicle are described in connection with the bronchi. The pulmonary artery lies more forward than the bronchi, while the pulmonary veins are placed still further in advance.—The phrenic nerve descends in front and the pneumogastric nerve behind the root of each lung.—The lung is freely movable at the anterior margin and at the base, but is less movable along the posterior surface. It is least movable at the apex.—The two lungs may touch each other at the upper part of the mediastinum, where in deep inspiration one may to a slight extent even overlap the other.

If a line be dropped downward from the origin of the posterior Scalene muscle to the base of the chest, at the top of the tenth rib, it will be found to divide the lateral cone of the chest equally. This is known as Conradi's line, after the observer who first described it. It is an interesting physiological fact in the mechanism of respiration that all those parts of the costal walls which are in front of this line move forward, while almost all those parts behind the line move backward during a deep inspiration.[1] When the individual is in the recumbent position, the lungs may be said to occupy the upper two-thirds of the thorax, since by reason of the convexity of the Diaphragm, the lower two-thirds of the figure of the thorax, as outlined in the undissected subject, are occupied by the liver, the spleen, and portions of the stomach.—The movements of the lungs in respiration produce considerable variations in the area of the cardiac region.—In a robust man the lower edge of the right lung is behind the lower edge of the sixth costal cartilage. In a slender youth it is behind the fifth intercostal space. Thence the base passes backward with a slight downward obliquity, crossing in succession the ribs and their interspaces from the sixth to the tenth.

"The lower edge of the left lung anteriorly is behind the sixth rib and cartilage. Thence it passes forward with a downward obliquity, crossing in succession the ribs and their interspaces from the seventh to the eleventh. In the robust it is a rib's breadth lower. During a deep inspiration, and when the lungs are distended after death to the full, the right base approximates nearly to the level of the left base. The difference between the right and left base is consequently but slight in those affected with emphysema, while it is often very marked in those affected with phthisis, in whom, indeed, the increased size of the liver presents an additional hindrance to the descent of the base of the right lung."[2]

The wedge of lung interposed between the Diaphragm and the ribs is larger posteriorly than anteriorly, owing to the base of the lung being lower behind than in front.[3]

In expiration the lungs do not ascend posteriorly beyond the inferior border of the sixth rib, and in front beyond the inferior border of the fifth rib on the right and the superior border of the sixth on the left side. The greatest height to which the lung is raised from the inferior *cul-de-sac* does not exceed an inch and three-quarters (seven cm.).

[1] Sibson, Med. Anat., Col. 38. See, also, Phil. Trans., 1846.
[2] Sibson, Medical Anatomy, Col. 39.
[3] Ibid., Col. 41.

Structure.—The minute anatomy of the lung is as follows: Each bronchial tube as it is about to terminate loses its regular succession of rings, their place being taken by isolated nodules of cartilage. These are irregularly distributed within the walls of the tube, but, as each successive bronchiole is given off, a particle of cartilage is seen at the point of bifurcation. The muscular coat is now lost, and the elastic coat with the mucous membrane is alone retained. The tube thus constituted is called the *syrinx*, and terminates in little pyramidal air-sacs or cavities (infundibula), which measure one-tenth of a line in diameter, those near the surface being the larger. The infundibula present a simple contour, but are furnished with rounded cavities, sixteen to twenty in number, which are called the *air-cells* (air-vesicles), and within which the mucous membrane is lost. Some of the air-cells are terminal, and others are arranged along the sides of the infundibula.

Fig. 188.



From a section through the lung of the cat stained with nitrate of silver. *a*, an infundibulum or alveolar duct in cross section; *b*, groups of polyhedral cells lining one part of the infundibulum, the rest being lined with flattened transparent epithelial scales; *c*, the alveoli lined with flattened epithelial scales; here and there between them is seen a polyhedral granular epithelial cell.

The basement membrane is thickly covered with a capillary network of the pulmonary system of vessels.

The septa between the infundibula are commonly entire, but may be perforated in the adult. The air-cells have a diameter varying from one-seventieth to one-two-hundredth of an inch.

Bloodvessels.—The lungs are supplied by the bronchial arteries of the aorta and accommodate the branches of the pulmonary artery.

When the passage of blood through the pulmonary veins is rendered difficult by pulmonary or cardiac obstruction,[1] the bronchial arteries, according to N. Chevers, afford to a limited extent a means of communication with the pulmonary arteries. The bronchial arteries may take the place of the pulmonary artery when the entrance of blood to that vessel is mechanically impeded. They are often enlarged in cyanosis.

An aortic branch from opposite the sixth dorsal vertebra sometimes goes to the right lung.[2] Small twigs pass to the under surface of the left lung.[3] Small pulmonary branches may be given off from the pericardial arteries.[4] From the right side of the abdominal aorta, in one case, a vessel entered the chest between the aorta and the œsophagus, divided into branches to supply the lower lobes of both lungs. Injection of the pulmonary artery showed free communication with this aortic branch.[5]

N. Chevers[6] determines that accessory aortic branches to the lungs "have been invariably determined by the existence of some considerable impediment to the circulation through the pulmonary artery during the earlier periods of cardiac development."

In some rare instances of closure of the pulmonary artery, the lung has secured its blood from the bronchial arteries. In a case reported by Cruveilhier,[7] in consequence of the pulmonary artery being rudimentary, the lung in like manner derived its blood from the aorta. Such enlarged bronchial arteries perform the function of the pulmonary artery (*supra*).

Nerves.—The nerves of the lungs are derived from the anterior pulmonary plexus of the pneumogastric nerve, and from the pulmonary plexus of the sympathetic system.

Lymphatics.—The lymphatics of the lung join the pulmonary and the bronchial glands.

Variations.—E. W. Collins[8] has given an account with the literature of the variations of the lungs. A supernumerary lobe near the apex of the right lung is determined by the position of the vena azygos. A lobe is mentioned as existing at the base of the lung, or in a space defined by the Diaphragm and the pericardium, the vena cava, and the vertebral column. Another is situated on the right or left side below the root of the lung. This probably is the analogue of the *lobus impar* of quadrupeds. The right lobe may be divided by a fissure.

[1] Lond. Med. Gaz., 3d S., iii. 1846, 287.
[2] Huber. Anat. Helvet., viii. 85.
[3] J. F. Meckel, Arch. für Anat. und Phys., vi. 454.
[4] Jacobson, Meckel, Anatomie, ii. 154.
[5] Sédillot, Recueil Period, xiii., and in Corvisart's Journ. de Méd, x.
[6] Loc. cit., p. 835, the above data are derived from this memoir.
[7] Anat. Path., liv. 1, pl. 6.
[8] Trans. Roy. Irish Acad., xxv. 1874.

The two lungs are somewhat broadly contrasted. The right lung is the larger, including the right bronchus. It ascends higher in respiration, and succumbs easily to diseased action.

The shape of the lung is impressed to a slight and variable degree by adjacent structures. The subclavian artery, *infra*, may create a faint sulcus upon the anterior surface of the apex. The median side of the lung is rendered somewhat concave by the vena cava on the right side, and by the lower portion of the thoracic aorta on the left.

Remarks.—The clinical remarks in connection with the anatomy of the lung may be embraced under the following heads: (*a*) the apex, (*b*) the root, (*c*) the base, and (*d*) the bronchial tubes.

(*a*) *The apex.*—The portion of the lung which is not confined by the thorax at the base of the neck is of course smaller in inspiration than in expiration. In robust individuals it is smaller than in those who are flat-chested.—The subclavian artery of each side passes over the front of the lung from one-half to one-third of an inch below the apex, and in some individuals creates a sulcus upon the lung surface.—The left upper lobe is shallower and narrower than the right. The result is that the percussion note above the clavicle is somewhat less resonant over the left than over the right upper lobe.[1]—In phthisis the altered form of the chest modifies the mechanism of coughing. The abdominal muscles and the Diaphragm by their long-continued use become disproportionately powerful, and tend to force the lung upward in the thorax. J. Hamernjik[2] has called attention to the loss of elasticity of the lung in long-continued illness accompanied by cough; while Gruber[3] has recorded several cases showing that, under the conditions above given, a cavity situated in the apex of the lung above the clavicle may be unable thoroughly to expel the contained air in expiration, or completely to discharge the liquid contents; and owing to the comparatively unprotected position of the apex, the walls of the cavity may project as a small triangular swelling at the base of the neck between the Sterno-Cleido-Mastoideus and the Anterior Scalene muscle.

(*b*) *The root.*—The root of the lung should be separated in clinical studies from the rest of the organ. Adhesions of any kind rarely occur here.—Lesions of the thoracic viscera not caused by the penetration of fractured ribs usually involve the lung and generally occur near the root of the organ.[1]—The left bronchus not only crosses the descending aorta and forms the lower limit, but it crosses the œsophagus as well. Both of these structures may excite diseased action at this place.—Owing to the fact that the aorta arches over the root of the left lung, this portion of the viscus is often compressed by aneurism of the aortic arch.

(*c*) *The base.*—The base of the lung is related clinically to the Diaphragm, the liver, and the spleen. It may be found adherent to the pleura of the Diaphragm, and may become involved in abdominal abscess which presses upward, and which may even open within the thoracic cavity, especially on the right side. Should the pleura of the base be adherent to the liver through the medium of the Diaphragm, such a collection may rupture within the lung-substance and be emptied through the bronchial tubes.

(*d*) *The bronchial tubes.*—The bronchial tubes may be constricted, as in asthma, from over-activity of the muscular fibres, or be over-dilated either through the inefficiency of these fibres or through degenerative processes in the remaining structures of their walls. The tubes, as they lie near or within the posterior mediastinum, are subject to compression from glandular, cancerous, aneurismal, and other growths, and may serve as conduits for blood and pus.

The lung may undergo congestion, partial collapse, and inflammation from the secondary effects of pressure by enlarged lymphatic glands (which are placed adjacent to the bronchial tubes) against the nerves of the pulmonary plexus.

W. Gull[2] narrates three cases of sloughing pneumonia following pressure against the pneumogastric nerves. J. P. Irvine[3] has found that the left bronchus is especially liable to compression by mediastinal tumors, particularly by those lodged in the walls of the œsophagus. When the main bronchus of a lung is gradually obstructed by tumors originating beyond its boundaries, or by intra-mural fibroid changes, the act of expiration is impeded, and emphysema, lobar collapse, destructive pneumonia, etc. ensue.

THE PLEURÆ.

The Pleuræ are two closed serous sacs which line the spaces containing the lungs. Each pleural sac may be said to occupy the corresponding side of the thorax. The space between the sacs has received

[1] Sibson, Med. Anat., Col. 37, 32.
[2] Prager Vierteljahrschr., 1845, iii. 72.
[3] Vier Beiträge zur Med.-Chirurg. Anat., Berlin, 1847, 41.

[1] T. Holmes, Surgical Diseases of Children, 247.
[2] Guy's Hosp. Reports, 3d series, 1859, v. 309.
[3] Lancet, 1878, pp. 415, 486, 563.

the name of the *mediastinum*. The left pleural sac, in consequence of the encroachment of the pericardium, is somewhat smaller than the right.

Each pleura may be said to present for examination a parietal and a pulmonic layer.

The *Parietal layer* is subdivided into a costal, a diaphragmatic, and a mediastinal portion.

The *costal portion* is the thickest of the three divisions, and covers the ribs and intercostal spaces.

The right costal pleura extends in front to the external end of the fifth rib, and covers in a considerable portion of the corresponding half of the sternum.

The *diaphragmatic portion* covers the Diaphragm. Between the root of the lung and the diaphragm extends a reflection of the pleura—the *ligamentum latum pulmonis*.

A small portion of the margin of the Diaphragm is not covered by the pleura, but is in direct contact with the wall of the thorax.

The *mediastinal portion* covers the median side of the lung, and is the most irregular of the divisions. It forms the lateral boundary of the several divisions of the mediastinum as it is defined from before backward. It covers the pericardium; and between the two passes the phrenic nerve. Anteriorly the mediastinal portion is in relation with the right internal mammary artery, and posteriorly, as it forms the side of the posterior mediastinum, it is in relation with the thoracic aorta and the œsophagus.

The pulmonary pleura is more adherent to the lung than is the parietal to the ribs; the diaphragmatic layer is also more adherent than the parietal.

The upper part of the right pleura terminates a little to the right of the median line of the sternum, and may even gain the left edge of the sternum. The left, on the contrary, may not reach further toward the median line than the first left costal cartilage.

The parietal *layer* covers the apex of the lung. It is here strengthened, according to Sibson, by a fascicle of the deep cervical fascia which extends from the transverse process of the last cervical vertebra to the inner border of the first rib.

The *Pulmonic layer* is thinner than the parietal, and is more translucent.

Beneath the costal and mediastinal portions a small layer of loose connective tissue is found, which is called the *subserous layer* (endo-thoracic fascia); it is but sparsely developed in the diaphragmatic and the pulmonic portions.

The right pleural sac, in addition to being the larger, is slightly shorter than the left. According to Luschka, it extends behind as far as the lower border of the ninth rib, while the left pleural sac reaches to the lower border of the tenth rib.

Zuckerkandl[1] found the pleura receiving fibres of insertion of a muscle which is known as the Scalenus Minimus. This muscle is described as arising from the transverse processes of the sixth and seventh cervical vertebræ (or the latter only), or the upper border of the first rib, and is inserted into the top of the pleura. Quain (ii. 508) gives a similar reference to Sibson.

Remarks.[2]—The superior *cul de-sac* is important from its relation to the subclavian artery. It is found in contact with the first rib for a distance of ten or twelve mm., and lies in contact with the subclavian artery from the region of the first intercostal space to the inferior cervical ganglion of the sympathetic and the anterior branch of the eighth cervical nerve.

During an operation for ligation of the right subclavian artery near its origin, Colles perforated the pleura with the aneurism needle. Bubbling of air in the wound and increased difficulty of respiration followed. Death occurred on the ninth day.

The following table is based upon a study of the extent of the pleura above the clavicles, including one hundred observations, by Dr. C. E. Isaacs:[3]—

The extent of the pleura above the clavicle in inches:—

	Right.	Left.
Sternal end,	1.19	0.95
Central portion,	1.42	1.23
Outer edge,	1.23	1.07

Lateral extent of the pleura above the clavicle:—

	Right.	Left.
Sternal edge from median line,	0.46	0.88
Outer edge from median line,	2.90	2.89
Width of pleura above clavicle,	2.88	2.01

In 14 cases it extended 2 in. above the clavicle.

In 5 cases it did not arise above the clavicle.

In 11 cases the inner edge of the pleura of the right side extended across and to the left of the median line.

The top of the pleural sac is not always dome-shaped, but sometimes forms *culs-de-sac* extending upward and sometimes laterally into the recesses at the root of the neck.

The subclavian artery in the third division of its course occasionally rests upon, or is in contact with, the pleura. This occurred in one case out of four.

[1] Zeit. für Anat. und Entwickelungsch., ii.

[2] The remarks and relations of the pleura to the ribs are treated of under one head.

[3] Trans. N. Y. Acad., 1857, ii. 3.

The pleura rises high in the neck of long-necked people, and, on the contrary, is low in the short-necked, and especially in "bull-necked" subjects.

The parietal pleura, owing to the presence of connective tissue already mentioned, is but slightly affected by injuries of the ribs. Even after fracture of these bones the pleura often escapes. According to Richet, traumatic emphysema is not apt to occur except when adhesions exist between the lung and the pleura covering the broken rib.[1]

Subpectoral abscess, axillary abscess, or tumor of the thoracic wall may involve the pleura through extension of the morbid process to the pleura by means of the subserous connective tissue.

The pleura, especially at the region of the thoracic aorta, the subclavian artery, and the œsophagus, will, by becoming greatly thickened in aneurismal and cancerous conditions, resist the invasion of diseased action; but when, by long-continued pressure, it suddenly yields, the fatal issue may be determined by copious hemorrhages into the pleural cavities, or by exciting acute inflammation therein of high grade.

In some cases of pleuritic effusion it is believed, by C. Ellis,[2] that the effusion instead of first collecting in the lowest part of the pleural sac, may, if small in quantity, occupy a conical portion of the pleural cavity in the sub-axillary region, under which conditions both normal resonance and the respiratory murmur may be wanting. In a certain number of cases where the effusion is quite large, if an accurate line be drawn, the flatness will be found to describe a curve gradually approaching the spine toward the base of the neck, leaving a space from one to three or more inches in breadth between the spine and the line of flatness. This is known as the curve of Damoiseau, who described it in the Revue Médicale in 1843. Although a feature of pathological rather than of anatomical interest, its evident relation to some structural peculiarity in the juxtaposition of pleura and thoracic wall warrants its introduction at this place. Reference may be made, also, in connection with this subject, to some experiments performed by G. M. Garland[1] in relation to the presence of fluid in the pleural cavities of the dog.

The pleura extends in the mammillary line to the sixth or the seventh cartilage. In the axillary line it extends to the lower border of the ninth rib on the right side, and to the tenth rib on the left.

Luschka estimates that the pleura does not pass downward to a point beyond the tenth rib. According to Holl,[2] however, it may reach the region of the twelfth rib. The pleura may be said to be longer than the lung by one inch. Hence it is possible for a perforating wound of the thoracic parietes to occur without injury to the lung.

THE MEDIASTINUM.

The interval between the right and left pleural sacs is called the mediastinum. It is arbitrarily divided into three compartments, a posterior, middle, and anterior, usually spoken of separately as the posterior, the middle, and the anterior mediastinum. For the relations of the structures contained in the mediastinum, the student is referred to the description of the several parts.

The *posterior mediastinum* is of an inverted pyramidal figure, the base lying at the superior thoracic aperture, and the apex at the Diaphragm. It is limited in front by the pericardium and the roots of the lungs, and is indented along its posterior margin by the forward projections of the bodies of the dorsal vertebræ.

The *posterior* mediastinum contains the œsophagus, the descending thoracic aorta, and a portion of the descending arch with the origins of the left common the carotid and subclavian arteries, the azygos vein, pneumogastric nerves, the thoracic duct, and the thoracic lymphatic glands and sympathetic ganglia.

The connective tissue which unites these structures extends along the vertebral column upward to the prevertebral region of the neck, guided chiefly by the œsophagus, and downward along the sides of the aorta to the retroperitoneal space of the abdomen. From this peculiarity the pus of a cervical abscess can communicate with the posterior mediastinum, as the

[1] Anat. Med.-Chirurg., 557.
[2] Boston Med. and Surg. Journ., 1874, xc. 15.

[1] Ibid., xci. 269.
[2] Archiv für klin. Chirurgie, xxv. 1880.

EXPLANATION OF PLATE CV.

Fig. 1. The relations of the parts within the interior of the thorax, seen from the left—the lung being removed.

Fig. 2. The same, seen from the right.

Fig 1

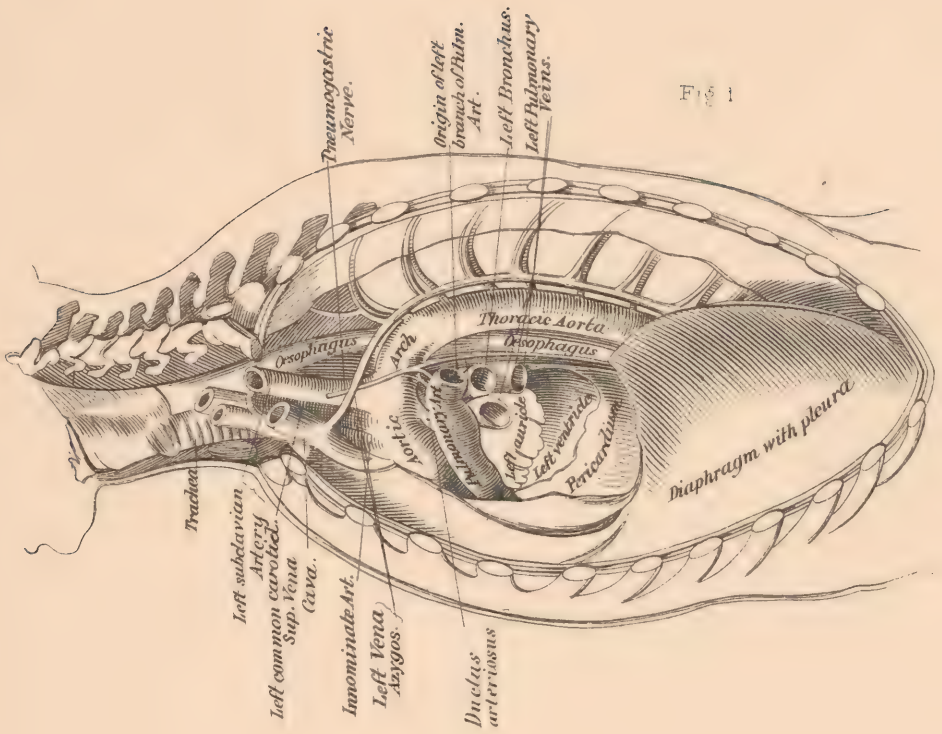
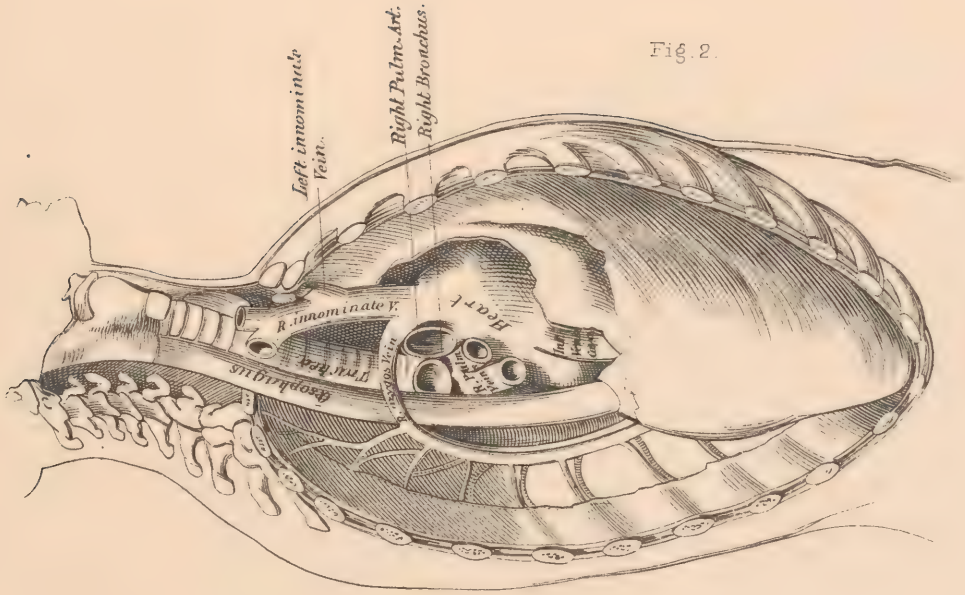


Fig. 2.



T. Sinclair & Son, Lith.

pus of a thoracic abscess may penetrate the abdomen. In like manner the blood escaping from a ruptured aneurism of the abdominal aorta may involve the posterior mediastinum. Ordinarily, the position of the bifurcation of the trachea limits the ascent or descent of fluid. Thus, a clot from the abdomen will reach to the line of tracheal bifurcation from below, while one from the neck, or upper part of the mediastinal space, will reach it from above.

Mr. Bristowe[1] has described an aneurism of the abdominal aorta, just above the cœliac axis, which in bursting caused blood to pass into the posterior mediastinum. The clot was confined to the lower half of the space.

Abscesses dependent upon caries of the vertebræ are found along the outer portions of the mediastinum, and the sheath-like connective tissue surrounding the region of the intercostal arteries and veins.

The *middle* mediastinum answers to the space containing the pericardium and its contents.

The space between the two pleural sacs contains the heart, the great arterial trunks at their origin, and the terminal portions of the great veins. The space is widest at its middle third, and abruptly diminishes in size above the heart.

The *anterior* mediastinum, as defined by English authors, is the interval between the sternum and the pericardium. All of the sub-manubrial connective tissue may without error be included in it according to continental writers, who speak of the anterior mediastinum as the space containing the connective tissue lying beneath the entire length of the sternum. It follows the inclination of the heart, being inclined from right to left. It is broader below than above. It is narrowest opposite the upper portion of the gladiolus, where, indeed, the two pleuræ may touch.

The anterior mediastinum contains, in addition to the connective tissue already mentioned, a small quantity of fat at its lower portion, the thymus gland in the infant and its remains in the adult, and the origin of the Sterno-Hyoid and Sterno-Thyroid muscles as well as of the Triangularis Sterni and of the left internal mammary artery.

Remarks.—The clinical study of the mediastinum embraces for the most part the anterior and the posterior portions. The anterior portion is a common site for development of sarcomatous tumors, and the posterior portion for cancerous tumors.[2] The posterior portion again, from the circumstance that it is in communication with the retroperitoneal space by the connective tissue and with the aortic and œsophageal orifices, may become involved secondarily by many diseased processes which have their origin in the lower portion of the trunk. The pus from a peri-nephritic abscess may thus pass upward into the posterior mediastinum.—The abdominal portions of the œsophagus, of the aorta, and of the thoracic duct may be the sites of the initial processes of disease which involve the thoracic portions secondarily.

[1] Trans. Path. Soc. Lond., x. 88.

[2] E. T. Bruen, Phila. Med. Times, 1884.

The Genito-Urinary Organs.

The Genito-Urinary Organs embrace
- The Kidney.
- The Bladder.
- The Male Organs of Generation.
- The Female Organs of Generation.

THE KIDNEYS.

The Kidneys are the principal organs of excretion. They are two flattened, elongated, bean-shaped bodies situated in the lumbar regions, in front of the last two dorsal and first two lumbar vertebræ, the right kidney being a little lower than the left, owing to the position of the liver. The average length of each kidney is about four-and-a-half inches, its width two inches, and its thickness one-and-a-quarter inch. Its weight is from four to six ounces.

The kidney is supplied by the renal artery, which enters the gland at a notch upon its inner side, where also, occupying a position behind the vessels, the ureter escapes. This notch has received the name of the *hilum*. Its posterior lip is less pronounced than the anterior, thus permitting the ureter to be exposed behind for a greater distance than in front. Extending from the hilum within the kidney are a chamber termed the *sinus*, containing some fat, and the subdivisions of the structures at the hilum. The anterior surface of the kidney is more convex than the posterior, and the lower extremity is slightly thicker and broader than the upper. The kidneys are not in the plane of a vertical section made from side to side, but are inclined to that plane in such wise that the outer margin of each is posterior, and the inner margin is anterior. Neither are they parallel to the vertebral column, since their upper extremities are slightly inclined toward each other.

A longitudinal section of the kidney exhibits a cortical and a medullary portion. The cortical is of a darker color than the medullary portion; both por-

tions are obscurely striated, an appearance best seen in the medullary. The cortical is not separated by any sharply defined line from the medullary portion, since here and there minute processes pass down a short distance into the medullary region, constituting the so-called columns of Bertini.[1]

The *color* of the kidney is a dark reddish-brown, externally. In *consistence* the organ is the most dense and also the most friable of the glands of the body. When moderately compressed the tissue breaks transversely. Each kidney is embraced by a capsule of thin fibrous tissue, containing elastic fibres. This covering is easily stripped from the normal organ, being attached to it only by small bloodvessels and minute connective tissue fibres. In certain pathological conditions, however, it becomes tightly adherent.

Relations.—Surrounding the kidney is a quantity of delicate adipose tissue, which is often called the fatty capsule (*tunica adiposa*). Behind, the kidney rests upon the lumbar fascia in great part, projecting slightly beyond its outer border, and to its inner side lying upon the psoas fascia, which in connection with the psoas muscle separates it from the vertebral column, and the crus of the Diaphragm, in front of the eleventh and twelfth ribs. It thus overlies the twelfth dorsal nerve as well as the transverse branches of the lumbar nerves. In front is the peritoneum, the relations varying on the two sides. Each kidney is surmounted by the corresponding supra-renal capsule. The right kidney lies behind the descending portion of the duodenum, the ascending colon, and sometimes the gall-bladder. The left lies behind the descending colon, which when contracted is placed to one side. The left kidney also possesses indirect relations in front with the spleen, the pancreas, and the stomach. In addition to this, the right kidney is in contact with a slight depression upon the under surface of the liver.—The lower extremity of the kidney is nearly in contact with the crest of the ilium. According to Holden, the kidney is opposite the two lower dorsal and two upper lumbar spines. The pelvis lies about on the level of the first lumbar vertebra. The upper border of the kidney is on the level of the interspace between the eleventh and the twelfth dorsal vertebræ. The lower border may reach a point as low as the third lumbar spine.—During deep inspiration both kidneys are depressed slightly.—The kidney can be palpated below the last rib at the outer edge of the Erector Spinæ muscle.

The medullary portion is composed of from ten to fifteen pyramidal masses (pyramids of Malpighi), whose bases are external, and whose apices project

Fig. 189.

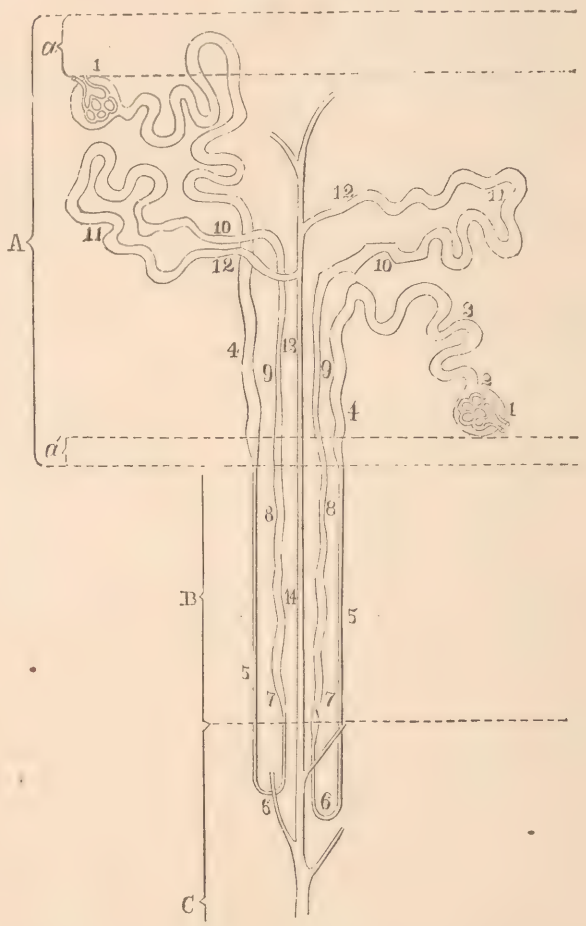


Diagram showing the course of the uriniferous tubules in the different parts of the cortex and medulla. A. Cortex limited on its free surface by the capsule; *a*, subscapular layer not containing Malpighian corpuscles; *a'*, inner stratum of cortex without Malpighian corpuscles; B, boundary layer; C, papillary part next the boundary layer; 1, Bowman's capsule; 2, neck of capsule; 3, proximal convoluted tube; 4, spiral part; 5, descending limb of Henle's loop-tube; 6, the loop itself; 7, 8, and 9, the ascending limb of Henle's loop-tube; 10, the irregular tubule; 11, the distal convoluted tubule; 12, the first part of the collecting tube; 13 and 14, larger collecting tube; in the papilla itself, not represented here, the collecting tube joins others, and forms the duct.

[1] These are absent in edentates, bats, apes, and some carnivorous animals, by reason of the confluence of the bases of the pyramids.

EXPLANATION OF PLATE CVI.

Fig. 1. The relations of the parts within the thorax, seen from in front, the anterior wall of the thorax, the lungs, and the heart in position.

Fig. 2. The same, seen from behind. The posterior wall of the thorax is removed, and the lungs pressed aside.

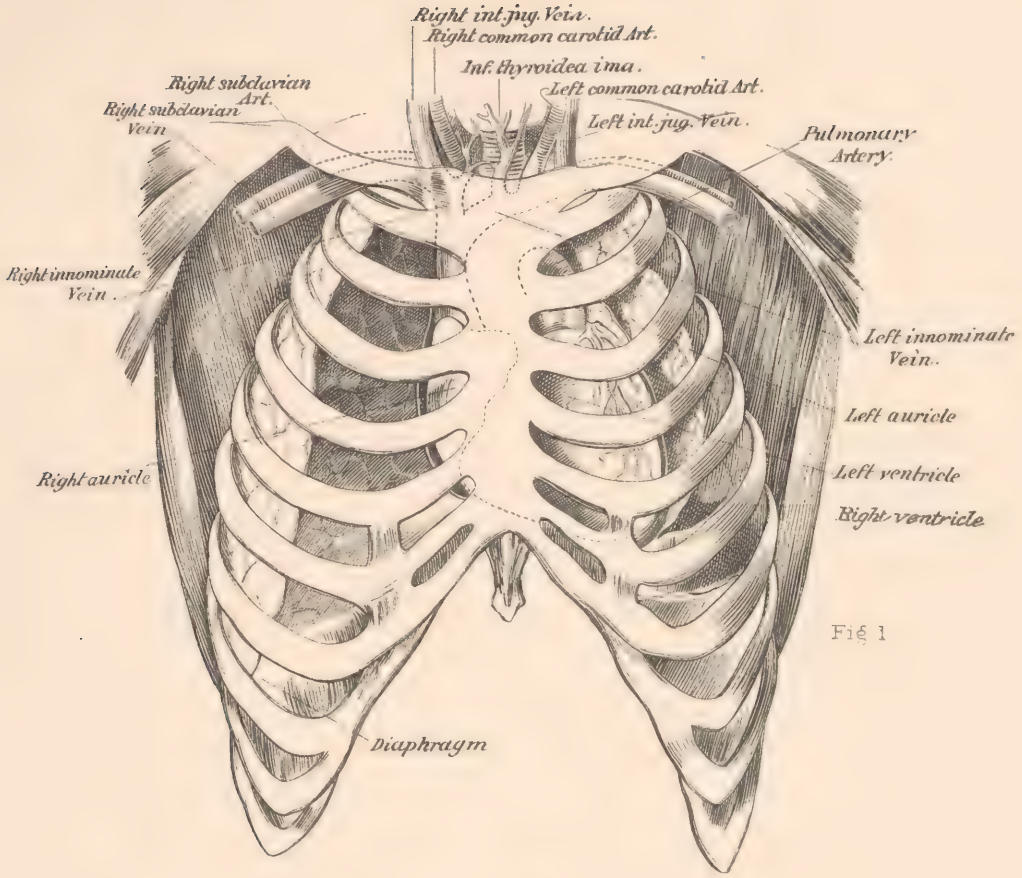


Fig 1

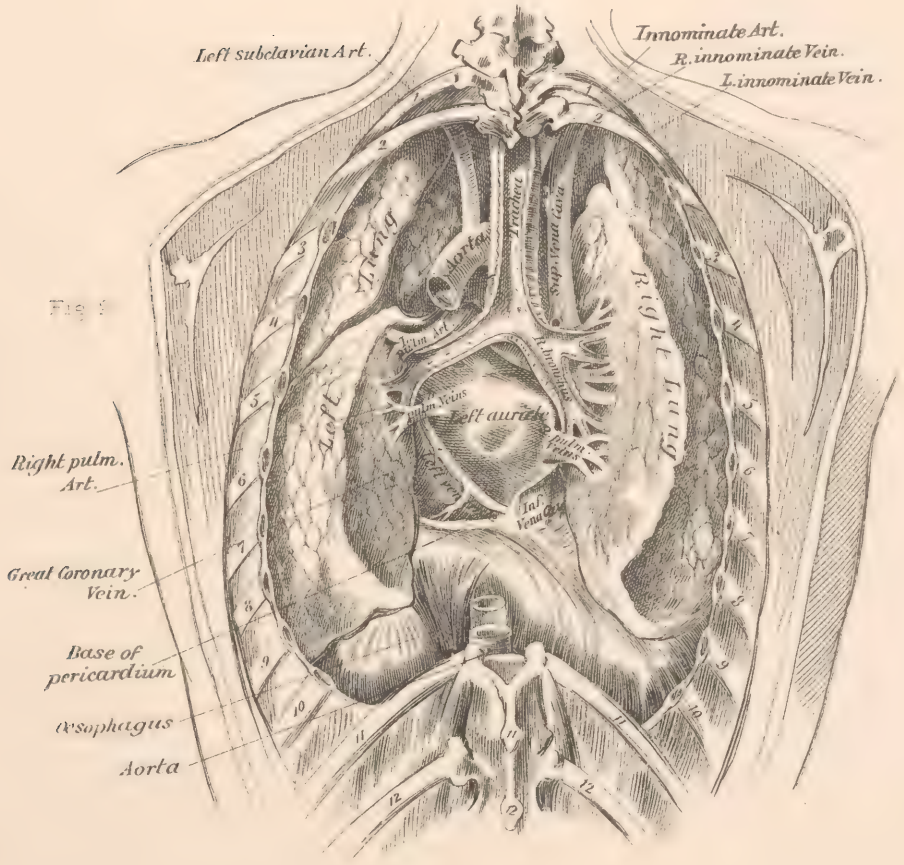


Fig 2

T. Sinclair & Son Lith.

into the pelvis, where they constitute the *renal papillæ*. Each pyramid is of a grayish tint, except at the papilla, where it is of a purplish-red. Each papilla is pierced by numbers of minute orifices, representing the termination of the excretory tubules (*q. v.*).

Minute structure.—The kidney is an association of tubular convoluted glands,—a pyramid representing a convergent group of closely related bundles of *uriniferous tubules* whose origin is in the cortex. The real divisions of the kidney structure, therefore, are not those of cortex and medulla, notwithstanding the apparent value of this distinction, but are between the pyramids or groups of the tubules; for it is between these that the arteries, nerves, and connective tissue secure access to the tubules, and by these in part that the veins and lymphatics escape; while in the fœtal kidney distinct lobulations are limited by the cellular interspaces.

Fig. 190.



From a section through the cortical substance of the kidney of a human fœtus, showing a Malpighian corpuscle. *a*, glomerulus; *b*, tissue of the glomerulus; *c*, epithelium covering the glomerulus; *d*, flattened epithelium lining Bowman's capsule; *e*, the capsule itself; *f*, uriniferous tubules in cross section.

A *uriniferous tubule* arises within the cortex by a bulbous expansion about a small rounded tuft made up of arteries and veins, the whole, vessels and envelope, being called a *Malpighian corpuscle*, which will be described under the head of the bloodvessels. The expansion of the tubule is called *Bowman's capsule;* the tuft of vessels, the *Malpighian tuft* or *glomerulus*. The tubule, as it leaves the glomerulus, becomes abruptly constricted, forming the *neck* of the Malpighian corpuscle, afterwards becoming tortuous, constituting the *tubuli contorti*. Farther on most of the tubules are observed to become contracted and to form long loops, *the loops of Henle*, which extend through the boundary layer to the margin of or even into the papillary portion of the medulla, and, returning to the cortex, again become widened and tortuous before emptying into the *straight tubules* (*tubuli rectæ*). Thence they pass directly inward to the pyramids of Malpighi. The lower portions of the uriniferous tubules present a diameter varying from $\frac{1}{240}$th to $\frac{1}{430}$th of an inch, the convoluted tubes and the smaller straight tubes, $\frac{1}{600}$th of an inch.

The raceme-like clusters of the Malpighian tufts and the tortuous origin and termination of the looped tubules give the characteristic expression to the cortex. When these parts are not aggregated near the superficies of the organ, but are diffused through the kidney, as is the case in birds and reptiles, no cortical portion exists. The groups of tufts and tortuous tubules form elongated masses broader without than within, and thus enable the straight tubes leaving the convoluted ones at the inner extremity of a cluster to enter the pyramids of Malpighi, while those at its upper portion will pursue a course almost equal to the entire thickness of the cortex before entering the pyramid.

Fig. 191.

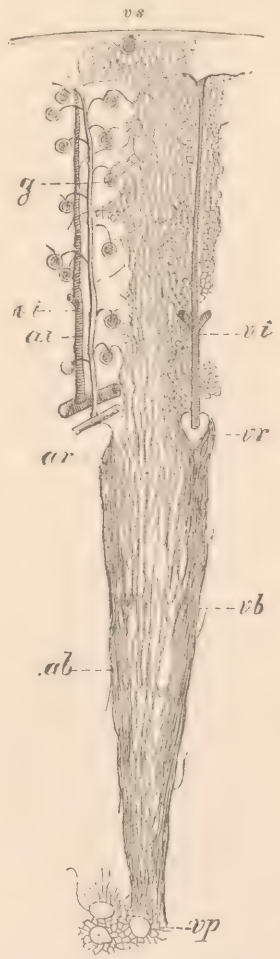


Diagram of the vessels of the kidney. *ai*, Interlobular artery; *vi*, interlobular vein; *g*, glomerulus of Malpighian corpuscle; *vs*, vena stellata; *ar*, arteriæ rectæ; *vr*, venæ rectæ; *ab*, bundle of arteriæ rectæ; *vb*, bundle of venæ rectæ; *vp*, network of vessels around the mouth of the ducts at the apex of the papillæ.

The collection of straight tubes between the groups of tufts and their convoluted tubules has received the name of the *pyramid of Ferrein*, *pyramidal process*, or *medullary rays*. Several of these correspond to the base of a

single Malpighian pyramid. They differ from the Malpighian pyramids by having their bases within and by being confined largely to the cortex. The central tubules in the former are parallel, while those in the pyramids of Malpighi are acutely convergent.

The epithelium in the straight tubes is columnar; in the other portions of the tubules the character of the cells is often obscured by their granular contents—the cells varying in shape from the scales lining the capsule to the low-columnar and cuboidal forms of the convoluted tubes, in certain parts of which a striation of the peripheral parts of the cells is described.

The Bloodvessels.—As already mentioned, the arteries of the kidney enter at the hilum, subdivide in the sinus, and the resultant twigs pass between the pyramids of Malpighi to their bases. They here form an imperfect anastomosis termed the *interlobular arch*, from which small arteries the interlobular arteries ascend to the cortex between the pyramids of Ferrein. From these interlobular arteries arise lateral stems, each bearing rounded berry-like knots of capillaries covered by a membranous envelope (the Malpighian corpuscles). Each of these presents a diameter ranging from the $\frac{1}{120}$th to the $\frac{1}{270}$th of an inch. The artery entering the corpuscle is called the *afferent* vessel, and the vein leaving it the *efferent* or *emulgent* vessel. The latter is somewhat smaller than the former, and soon breaks up into a network of veins which ramify among the uriniferous tubules, becoming elongated among the straight tubes, and forming at the bases of the pyramids an anastomosis termed the *interlobar veins*. From these arise the veins of exit which pass from the gland to the veins of the sinus. Upon the cortex some of the smaller venules terminate in *stellate veins*, which in some degenerative conditions form conspicuous objects on the surface of the kidney. Each vein is composed of from five to six branches whose extremities are lost in the intertubal network.

Upon the papillæ a delicate venous network is seen having an arrangement somewhat different from that between the tubes, with which, however, it is continuous.

It will be seen that the network lying between the emulgent veins of the Malpighian tufts and the renal vein is comparable to the hepatic network intervening between the portal and hepatic veins, and has sometimes received the name of the portal network of the kidney. Ludwig and Zawarykin[1] have shown that the supply of the kidney is not in all respects dependent upon the renal artery, since a partial injection of the kidney of a dog was effected after tying the renal artery.

The *lymphatics* of the kidney are of two sets, a superficial and a deep, which freely anastomose.

The connective-tissue stroma is poorly developed in the adult kidney. It extends between the tubules and the bloodvessels, and is more marked in the immediate vicinity of the Malpighian corpuscle than elsewhere in the cortex; but on the whole the connective tissue reaches the highest development in the papillary portion of the medulla. Its scanty presence may serve to explain the fragility of the organ.

Variations.—The kidney may vary in position from the one assigned as normal. The organ may be occasionally movable from one of two causes, either from the organ being enveloped in peritoneum when a true meso-nephron exists, or from the absorption of fat from about the kidney.

The kidney may be divided transversely, each division possessing a separate ureter. There may be more than two kidneys on each side, imperfectly joined. Double ureters may exist with an otherwise normal kidney.—The union of the two kidneys is ordinarily accomplished by an isthmus of crescentic outline, joining the lower borders, the concavity being directed upward. Such malformations are known as *fused* or *horse-shoe kidneys*. According to R. P. Harris,[1] this term has also been given to a single kidney of an unusually curved form. In a specimen of fused kidney exhibited before the Pathological Society of Philadelphia[2] by Thos. G. Morton, the greater part of the mass was situated upon the left side of the vertebral column, the concave edge presented downward, and the hilum was situated upon the lateral border.

After an elaborate study of the recorded cases of misplaced and movable kidney, A. E. Durham[3] has arrived at the following conclusions: "Fixed misplacement of the kidneys is usually congenital, as is indicated, among other considerations, by the corresponding irregularities presented by the renal bloodvessels. The left kidney is more liable to fixed displacement than the right; and its misplacement is usually associated with malposition of the colon. The right kidney is more frequently movable than the left. Women are more liable to the affection than are men."

The kidney may be placed lower than is normal, being found as far down as the crest of the ilium, or even within the cavity of the true pelvis. Congenital misplacements of the kidney are commonly met with. The position of the renal vessels should be carefully observed in dissection of these subjects. Hyrtl affirms that, if the vessels have their normal relations to the great trunks, the malposition is acquired. If, however, they be shown to be abnormal, the malposition is congenital. A congenital pelvic kidney may receive its blood from the aorta and the common iliac artery.

The kidney may be absent on one side. The remaining organ is then termed *single* or *solitary* kidney. Drs. Willard, Packard, and Reed[4] found that out of twenty-one cases, references to which are given, the left kidney was absent in

[1] Wiener Acad. Sitzungsbericht, xlviii. 1864.

[1] Proc. of the Path. Soc. of Phil., 1860, 81.

[2] Loc. cit., p. 77.

[3] Guy's Hospital Rep., 1860, iv. 420.

[4] Proceedings Pathological Society of Philadelphia, 1870, 172.

seventeen, the right in four. The kidney at birth contains crystals of urate of soda.—The detection of such crystals has no value in forensic medicine, since they are by no means confined to the fœtal gland, but may be found as late as the forty-fourth day.[1] — The absence of one kidney may be associated with anomalies of the sexual apparatus. O. Beumer[2] found as a result of an analysis of forty-eight cases that one-half were in males.

Remarks.—A correct impression of the relations of the kidney is often important in interpreting the effects of lesions in the loins. Thus, from the fragility of the organ, rupture of the gland substance may follow indirect violence. The clot of blood which forms after such accidents lies between the kidney and the peritoneum anteriorly, and has been known to form a tumor of sufficient size to press against the colon and to interfere with the passage of the feces. It is hardly possible that the colon should altogether escape severe local pressure from the fact that it overlies and is close to the injured renal organ.[3]

The relations of the right kidney to the liver may determine the site of pain in nephritis by the descent of the liver in inspiration, as suggested by Cruveilhier. The organ may be pushed downward by an enlarged liver.[4]

The extensive communications of the connective tissue about the organ with remote points determine the directions which pus may take in suppurative peri-nephritis. Thus the pus may pass downward along the course of the Psoas muscle (*q. v.*), and appear at the groin; or upward between the pillars of the Diaphragm, where it may cause adhesions to form between the layers of the pleura; or may penetrate the pleural cavity and even empty into the bronchial tubes.

In a case recorded by Renard,[5] a penetrating gunshot wound of the trunk involved the right kidney and caused a urinary fistule to be established through the wound of exit. An abscess subsequently formed within the right lung which communicated by several openings through the Diaphragm with the upper portion of the kidney. The patient survived ninety days. According to A. B. Duffin,[6] the position of the thigh in peri-nephritic abscess differs from that seen in psoas abscess in the circumstance that the pelvis is tilted "up to the utmost in peri-nephritic abscess in order to relax the lumbar fold."

[1] J. Hodann, Vierteljahrsschrift für gerichtl. und öffentl. Medecin, 1855, 33.

[2] Virchow's Archiv, 1878, 344.

[3] Jno. Hilton, Guy's Hosp. Reports, 1867, 17.

[4] Rayer, Traité des Mal. des Reins, 799.

[5] Gaz. des Hôpitaux, 1861, 202.

[6] Trans. Path. Soc. Lond., 1873, 138.

THE EXCRETORY APPARATUS.

The Excretory Apparatus of the kidney begins by numbers of membranous tubes which embrace the papillæ and secure attachment to the free projecting portions of the pyramids. These have received the name of the *lesser calices*. They quickly unite to form two or three separate convergent portions, the *greater calices* (infundibula), and these terminate in a pouch-shaped expansion of the ureter, termed the *pelvis* of the kidney. The remaining portion of the excretory channel, namely, that lying between the pelvis and the bladder, constitutes the *ureter*.

The Ureter is a membranous tube from fourteen to eighteen inches in length, extending downward and inward, so as to lie obliquely across the psoas fascia. At the margin of the true pelvis the ureter crosses the origin of the common iliac vessels, at times on the right side the origin of the external iliac artery only.

The spermatic vessels lie in front of the ureter, and, near its termination in the male, the vas deferens lies to the inner side. The right ureter lies close to the outer side of the inferior vena cava.

The ureter, as it lies within the pelvis, is four-and-three-quarters inches (twelve cm.) long. The left ureter crosses the left common iliac artery about three-quarters of an inch (one-and-a-half cm.) above its termination, and is a little nearer the median line than is the right.

Within the true pelvis the ureters rapidly converge and narrow in calibre till they enter obliquely the inferior portion of the posterior surface of the bladder, each by a small slit-like orifice from one-and-a-half to two inches from its fellow.

The oblique direction of the ureter through the wall of the bladder has the effect of a valve in preventing regurgitation of urine from the bladder.

In the female the ureter at the last portion of its course lies between the neck of the uterus and the bladder, and hence that portion engaged within the walls of the last-named structure is liable to be compressed by the neck of the uterus. Luschka affirms that in pregnancy a physiological dilatation of the ureters results from this relation.

Structure.—The minute structure of the ureter shows an external fibrous layer, a middle layer of longitudinal and circular muscular fibres, and an inner or

mucous layer. The epithelium is of the stratified transitional type.

Variations.—The variations of the ureter are unimportant. The ureter may be double; very rarely three ureters pass out from a normal kidney.

Remarks.—Compression of the ureters in cancer of the uterus often results in their enormous dilatation.—In obstruction to the outflow of the urine, either from stricture or disease of the bladder, the valvular character of the cysto-uretral orifice is destroyed, and the ureter becomes dilated.—Velpeau[1] mentions a case in which a pin, lodged in the colon, had penetrated the ureter, and had collected upon its free projecting portion a quantity of calculous matter. It is thus possible for foreign bodies, which may have effected entrance into the ureter or the bladder from the intestinal canal, to serve as nuclei for calculus.

In marked examples of dilatation, such as occur from occlusion by pressure, the ureter may assume a spiral form a short distance from the kidney, so that a valvular arrangement results which is of itself sufficient to prevent the escape of urine from the pelvis of the kidney.[2]

Luschka[3] enters into a careful study of the relations, anatomical and clinical, of the ureter in the female. The following is an abridgment: The right ureter lies at first behind the end of the descending portion of the duodenum, so that these organs may communicate abnormally. The left ureter descends behind the duodeno-jejunal flexure; it may effect an abnormal communication with the sigmoid flexure.

In a woman aged twenty-nine years, coming under the author's observation, it was noticed that, after recovery from pelvic cellulitis, a swelling developed in the left iliac region, near its junction with the lumbar region. A urinary fistule was established which discharged urine and feces. No bladder symptoms were present, and the urine which escaped was perfectly normal. It was thought that a fistulous communication had been established between the left ureter and the sigmoid flexure. The patient recovered.

In deviation of the pregnant uterus from the median line to the right side, owing to malposition of the rectum, the right ureter is apt to be compressed. The pelvic portion is in part surrounded by the peritoneum, and in part by parametritic venous plexuses, which spread out from near the supra-vaginal portion of the uterine neck, the base of the broad ligament, and the vaginal vault.

At the base of the broad ligaments, the ureters are applied to the pelvic wall, the left to the inner side, the right to the outer side of the internal iliac artery of the corresponding side.—After leaving the lateral wall of the pelvis, each ureter crosses the round ligament and pierces the venous plexus at the side of the vagina and the neck of the uterus, where it is in relation with the uterine artery. The ureter forms a faint sigmoid curve near the supra-vaginal portion of the cervix, and finally approaches to within about five-eighths of an inch (one-and-a-half cm.) of the anterior wall of the vagina, and crosses the lateral surface of this passage at an acute angle. The proximity of the ureter to the vagina increases as the former passes downward and inward toward the median line at the bladder. At the level of the internal os the ureter is one inch (two-and-a-half cm.) distant. At the supra-vaginal portion it lies three inches and three lines (eight cm.) from the vagina, and at the vault of the vagina two and three-eighths inches (six cm.). Thus retroflexion of the uterus may give rise to pressure upon the ureter.—In pronounced distension of the bladder the ureters are closely approximated to the anterior wall of the vagina. When the bladder is contracted the peritoneum not only covers in the anterior wall of the entire supra-vaginal portion of the cervix, but also overlies the vault of the vagina, a thin layer of subperitoneal connective tissue alone intervening. This tissue, while the bladder is distended, lies between that organ and the uterus.

An excellent example of a fistule connecting the ureter with the uterus is described by Freund.[1] At the autopsy the left ureter as it approached the cervix

[1] Anat. Chir., ii. 175.

[2] Chas. J. Hare, Med. Times and Gaz., xiv. 1857, 233.

[3] Archiv f. Gynäkologie, iii. Heft 3, Taf. ix.

[1] Klin. Beiträge zur Gynäcolog. Heft 1, 108, No. 14.

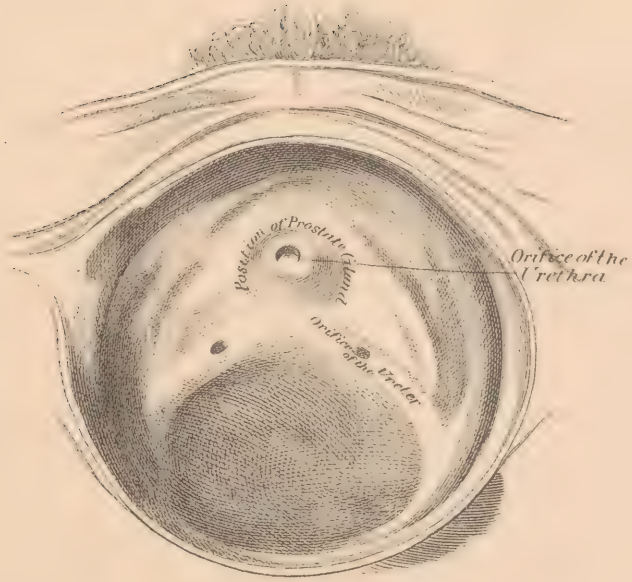
EXPLANATION OF PLATE CVII.

Fig. 1. A diagrammatic representation of the kidney, seen in a vertical transverse (frontal) section.

Fig. 2. The bladder bisected, so as to display the fundus.



Fig 2



T. Sinclair & Son Lith.

uteri was found surrounded by indurated connective tissue. Within this mass was an ill-defined cavity into which the ureter opened, and connecting this cavity with the canal of the cervix was a canal of the fineness of a hair; above the ureter was dilated.

A hydatid tumor may compress the ureter within the pelvis. Mr. Murchison[1] describes a cyst lying behind the uterus and forcing this viscus down so as to cause it to appear at the vulva. Another smaller cyst was found in the same subject lying at the right side of the pelvis. The ureters were compressed, and the pelves of the kidneys slightly dilated. The kidneys were small and granular.

With respect to the lesions of the ureter A. Poland[2] presents the following excellent summary:—

"The only vulnerable parts of the ureter are its commencement at the pelvis of the kidney, and the first few inches of its course. Here it is situated in the loin, and may undergo stretching from inordinate torsion of the body, or may be exposed to external violence from severe contusions in this region. Hence in all cases recorded, injury to the ureter has been found close to the kidney. The ureter may be ruptured by severe contusions without lesion of any other important structure, the escape of the urine into the cellular tissue behind the peritoneum inducing peritonitis. This condition may be complicated with lesion of the kidneys and other important structures. The ureter has also been injured by penetrating wounds, and may be obliterated by diseased action."

The ureter is so intimately united with the tissues involved in ovarian and uterine disease that it may be opened or ruptured in ovariotomy and related operations. Such an accident occurred to Simon, who cured the urinary fistule thereby established by excision of the corresponding kidney. Von Nussbaum relieved a similar condition by deflecting the fistulous tract into the summit of the bladder.[3]

THE BLADDER.

The Bladder (fig. 2, Plate LXXIV.; fig. 2, Plate CVII.; figs. 3 and 4, Plate CVIII.; fig. 3, Plate CIX.; and Figs. 194 and 195) is the reservoir for urine. It is an elliptical or egg-shaped sac projected from the front of the genito-urinary tract between the termination of the ureters and the origin of the urethra.

Its capacity varies greatly, but may be said to range from six to thirteen ounces. It has been frequently asserted that the bladder of the female is larger than that of the male. While it is true that with some females the bladder may be larger, it is now believed that the average capacity of the female bladder is actually less than that of the male.

The longest diameter of the bladder is vertical, namely, from the base to the summit. The greatest transverse diameter of the bladder in the female is three-fourths of an inch to one and one-fifth inch above the internal orifice of the urethra.[1]

The posterior surface is more convex than the anterior, and the entire viscus is somewhat compressed from side to side. When seen from before the bladder is of a triangular shape. It is reasonable to suppose that in the living state the weight of the intestine must tend to flatten the summit and in part the posterior wall.—When empty the bladder of the female is collapsed, the sides and summit are in contact, and on section the cavity presents the appearance of a mere chink.

The bladder is divided topographically into the summit, the sides, and the base, and presents an anterior and a posterior surface.

The *summit* (superior fundus) is rounded, covered with peritoneum, and continuous with the cord representing the remains of the urachus, which ascends as far as the umbilicus. The *lateral surfaces* (sides) are in contact with the true lateral ligaments derived from the recto-vesical fascia. In common with the preceding they are covered with peritoneum.

The *base* (inferior fundus, bas-fond) is directed toward the perineum, and is in relation with the rectum of the male, and the neck of the uterus and vagina in the female. The former relation is confined to a small triangular space having the vas deferens and vesiculæ seminales at the sides, and the prostate gland in front. The *cervix* or *neck* of the bladder is a term used to signify the region directly behind the internal urethral orifice.—The *anterior surface* projects a short distance above the pubis, but is not covered with peritoneum. It forms an angle with the base at the urethral orifice. In front are the pubis and a delicate layer of fat.—The *posterior surface* of the bladder is continuous with the base.

In addition to the relations of the peritoneum already noted, there remain to be mentioned the folds of that membrane which extend from the bladder to associated parts. These are five in number, and are known as the *false ligaments of the bladder.*

[1] Diseases of the Liver, 109.

[2] Guy's Hosp. Rep., 1868, 85.

[3] Aerztliches Intell.-Blatt, 1876, Nos. 7 and 8. Trans. in Ed. Med. Journ., 1876, July 1.

[1] Pansch, Archiv f. Anat. u. Phys., 1874, 702.

The *superior* ligament lies between the hypogastric arteries, and extends from the summit of the bladder to the umbilicus.

The two *lateral* ligaments extend from the sides of the pelvis to the walls of the bladder.

The two *posterior* ligaments (recto-vesical) extend from the rectum to the sides of the bladder.

Under the name of the *true ligaments* may be mentioned processes of the pelvic fascia situated at the sides of the bladder. These are four in number, two anterior and two lateral. The two *anterior ligaments* (pubo-prostatic) extend from the symphysis pubis to the front of the bladder and the prostate gland. Each contains a small muscular slip from the bladder. The *lateral ligaments*, one on either side of the bladder, extend from the pelvic fascia covering the Levator Ani muscle to the prostate gland and the bladder.

The internal surface of the bladder is smooth, when the organ is filled with urine, but wrinkled when empty, excepting at its base, which is at all times nearly smooth. The basal surface (trigone) corresponds to the triangular interval between the uretral and urethral orifices.

In the female this space is smaller than in the male by reason of the absence of the prostate gland.

At the urethral orifice is a slight median elevation known as the *uvula vesicæ* (luette). When the bladder is empty the position of this portion of the base is marked by a few longitudinal plications, and extending across between the uretral orifices is a faint inconstant elevation, due to the muscular coat.

The connective tissue beneath the mucous membrane is abundant, and beneath it in turn is the muscular coat.

The *muscular* coat is composed of three layers, the *longitudinal* layer (external layer), which is best developed upon the anterior and posterior surfaces; the *circular* layer, which being well defined at the neck (Sphincter Vesicæ) becomes weaker, above and behind than in front, and its fibres are more or less decussating near the summit; and a *submucous* layer (internal layer), which is composed of delicate longitudinal fibres, and is best developed at the summit of the bladder.—According to Jurie,[1] the longitudinal fibres are so related to the sphincter that when the former contract the sphincter is pulled open.

The epithelium of the bladder is composed of small rounded cells, from among which pyriform cells arise by their small ends, and bearing upon their swollen ends large capitate cells, which are larger than those of the deeper layers. Thus the ureters and bladder are possessed of an epithelial lining similar in character.

Relations.—The position of the bladder can be determined by the finger in the rectum, at which point the surgeon can detect that portion of the angle which forms the apex of the trigone. This is the spot, according to Holden,[1] at which the distended bladder should be punctured through the rectum.

J. G. Garson[2] has written an extended account of the alterations of the position of the bladder due to distension of the rectum.

Variations.—Ectrophy of the bladder is that condition in which the anterior wall as well as the corresponding portion of the abdominal parietes is absent. The posterior wall of the bladder is thus exposed, and brought nearly to the level of the anterior contour of the trunk. The orifices of the ureters are of course exposed.

The umbilical termination of the urachus may be patulous in the infant, permitting urine to escape. The urethra may be closed in some examples of persistent urachus, or where tight congenital phimosis exists, the urine in either case escaping entirely by the umbilicus. More frequently both are pervious, the greater portion of the urine being voided by the urethra.[3] The urachus when patulous may become cystiform. C. E. E. Hoffmann[4] describes a striking instance of this variety, in which four separate tappings of the sac were instituted, each being followed by the escape of large quantities of fluid. After death the bladder was found contracted, and the urachus closed at its vesical end, while its middle portion was enormously distended, thickened, and lined with pavement epithelium.[5]

According to Luschka,[6] the urachus is essentially a hollow tube. Observers have occasionally found calculi lodged within this canal.

Remarks.—The bladder possesses a tendency to sacculation. A variable portion of the wall may be thus depressed, and afford favorite sites for the deposition of calculi.

In some rare instances, the sacculations which occur at the side of the bladder may become ingredients of an inguinal hernia, or scrotal hernia,[7] or assume various abnormal positions. In a case mentioned by C. Mur-

[1] Stricker's Hdbuch., iv. 1873.

[1] Landmarks, p. 76.

[2] Edin. Med. Journ., 1878, xxiv. 300.

[3] Guéniot, Bulletin de Thérap., Oct. 1872.

[4] Archiv f. Heilkunde, 1870, 373.

[5] For a *résumé* of the subject of persistent urachus, see A. Rosé, N. Y. Med. Rec., xii. 516.

[6] Virchow's Archiv., 1862, xxiii. 1; also Luschka's Anatomie, 229.

[7] G. Pilcher, Trans. Path. Soc. London, 1853, iv. 187.

chison,[1] the sacculated portion extended within the abdomen as far as Poupart's ligament, where it pressed upon the femoral vein, and excited inflammation of its walls.

An ovarian or other tumor growing upward from the pelvis is liable to carry with it the upper portion of the bladder, and compress it against the abdominal wall. Median incisions in the hypogastric region in such cases should be guardedly made, since the thinned and emptied viscus can with difficulty be distinguished from surrounding tissues.

Rupture and distension of the bladder, while strictly surgical subjects, present some underlying anatomical features which may be here briefly epitomized: when distension occurs as the result of a slow process, the walls of the bladder become thinned, and an interstitial spontaneous rupture may occur which will be confined to the muscular and mucous layers—a pouch defined by peritoneum receiving the urine. This pouch is generally upon the posterior surface as a natural result of the absence of that support which the anterior surface, and in part the lateral surfaces, receive from the abdominal walls, as well as from the fact that at the sides the peritoneum is tense and comparatively unyielding. For similar reasons the posterior wall is most liable to be ruptured after violence. Nevertheless, in many cases the site of the lesion holds a fixed relation to the direction of the force. This force may rupture all the coats of the viscus. Following such an accident upon the anterior surface, the urine will escape into the subperitoneal connective tissue of the abdominal wall (*q. v.*). The rupture occurring inferiorly will cause the urine to infiltrate the perineum, provided the recto-vesical fascia has yielded; and posteriorly it will cause the urine to flow into the peritoneal cavity. Rupture from beneath is liable to be associated with laceration of the urethra (*q. v.*), this canal being made tense by the upward inclination of the distended bladder. Thus the bladder may be ruptured from a kick in the perineum. Erskine Mason[2] describes this accident as occurring in a boy. The bladder was ruptured at the side near the neck, and the urethra was lacerated. In an interesting accident reported by Mr. Thompson,[3] the laceration was incurred by the patient falling on his back from a height of twenty feet, and a heavy mass of earth directly afterward crushing the abdomen. The bladder was found ruptured, and the perineum lacerated. The external wound was sufficiently large to permit three fingers to be passed with ease through it into the bladder. The observer, in commenting upon the case, concludes: "It is evident that the weight and pressure of the earth compressed the bladder so completely within the pelvis, that the urine was sent forward with such force as to tear the urethra and the perineum."

Thomas D. Jones[1] reports a curious example of closure of the opening in a ruptured bladder by a portion of bowel.

In the female, rupture of the bladder, according to Harrison, is rare, for the following reasons:—

"The viscus does not incline backward to the degree seen in the male, but enlarges forward and in the transverse direction. The uterus and its lateral folds assist in breaking the shock of any external violence applied to the hypogastric region, and to prevent the direct concussion of the bladder against the promontory of the sacrum."

Distended bladder naturally displaces the uterus upward and backward, and may thus act as a factor in preventing contraction of the uterus after delivery. Geo. T. Elliot[2] includes this condition among the causes of post-partum hemorrhage.

Inflammations of and extravasations into the tissues of the pelvis of women lead more frequently to the evacuation of the products of diseased action through the bladder than in men.[3]

The contraction of the muscular coat of the bladder has a direct influence in closing the ureters and preventing regurgitation during the emptying of the viscus.[4]

THE PROSTATE GLAND.

The Prostate Gland (prostate body) is a collection of racemose glands surrounded by a firm symmetrical musculo-cellular stroma. It embraces the urethra from the neck of the bladder to the triangular ligament, a distance of one-and-one-eighth to one-and-one-fourth inches, at the same time receiving the utricle and the ejaculatory ducts.

It lies immediately in front of the rectum at about its middle third, at which point it can be readily felt. The gland resembles in outline a truncated cone, and presents a base and an apex, as well as anterior, posterior, and lateral surfaces.

[1] Trans. Path. Soc. Lond., xiv., 1863, 133.
[2] N. Y. Med. Journ., 1874, 638.
[3] Prov. Med. and Surg. Journ., Oct. 20, 1851.

[1] Lancet, Aug. 20, 1870, 252.
[2] N. Y. Med. Journal, April, 1867, 35.
[3] Ibid., 41.
[4] Jurie, Stricker's Med. Jahrbücher, 1873, iv.

The *base* is notched in the median line for the entrance of the urethra; in advance of this is a single funnel-shaped depression for the ejaculatory ducts.

The *apex* is adherent to the triangular ligament, and is surrounded by the anterior fasciculi of the Levator Ani muscle.

The anterior and posterior surfaces are broader than the lateral, and are but slightly convex. The *anterior surface* is in contact with the pubo-prostatic ligaments—median and lateral—and with the connective tissue behind the symphysis pubis. The *posterior surface* is separated from the rectum by the prostatico-peritoneal aponeurosis, or recto-vesical fascia. The *lateral surfaces* are convex, and the posterior form with the posterior notch two more or less pronounced masses which slightly diverge. These are the *lateral lobes* of the prostate.

The points of union of the lateral portions at the floor of the urethra, both in front and behind the orifices of the ejaculatory ducts, form two transverse connecting tracts which H. Thompson proposes to designate as the *anterior* and the *posterior commissures*. The anterior commissure is always inconspicuous, and never seen without first stripping off the mucous membrane. It is poor in gland tissue—some writers, indeed, as Thompson and Jarjavay, denying its existence. The posterior commissure, on the other hand, is rich in glands and is noted as the site of frequent enlargement, being then denominated *the middle lobe*. Since it is of importance to employ a correct terminology in describing a locality which is so often the seat of hypertrophy, Thompson has suggested that it be termed *the median portion*, the so-called *middle lobe* being simply an outgrowth of prostatic tissue at that point.

Development.—A proper understanding of the prostatic lobes demands a knowledge of the origin of the entire organ. Up to the fourth month of intrauterine development the prostate gland is represented by a pair of oval bodies, one on either side of the urethra. These subsequently unite in great part, but leave, in the *lateral lobes*, evidence of the original symmetrical duplicature of the organ.

Measurements.—The prostate gland measures in the young healthy adult about one-and-three-quarters in width, and seven lines in thickness. In consequence of its truncated form, the base exceeds by a fourth or a fifth the measure of the longitudinal axis. It weighs from four to six drachms.

Structure.—On section the gland is seen to be yellowish-white or reddish-gray in color. The *glands* are not seen at a superficial inspection, but require to be studied carefully with the microscope. They are from twenty to thirty in number, and belong, as already mentioned, to the racemose type. They differ, however, from the salivary and duodenal glands, examples of the same type, in having the secreting follicles relatively few in number and irregularly disposed. The orifices of the glands open about the outer sides of the orifices of the ejaculatory ducts.

According to W. Soetlin, it would appear that the prostate is a conglomerate gland, the gland being tubular, not racemose.[1]

The *stroma* makes up the bulk of the body. It is composed of a fibroid tissue containing some elastic fibres, among which are placed unstriated muscular fibres. The latter form two sets of fibres; a longitudinal and a circular set. The *longitudinal* lie immediately beneath the mucous membrane and are continuous with the sub-urethral muscle elsewhere described. The *circular* fibres are more thinly disposed than the preceding, but become thicker posteriorly, where they are traceable into the circular layer of the muscular coat of the bladder. These form at the neck of that viscus, the Sphincter Vesicæ. According to Pettigrew, the circular fibres belong to figure-of-8-like loops, the complements of which are to be seen in the walls of the bladder.

The urethra as it passes through the prostate gland receives the name of the *prostatic portion*. It will be fully described under the head of the Urethra. In connection with this, it may be stated, however, that the greater portion of the prostate lies behind the urethra, and that the ejaculatory ducts (see Testicle), pierce the post-urethral portion obliquely upward and forward, to open on either side of the orifice of the *utricle*.

The prostate gland is surrounded by a proper capsule or fascia which adheres intimately to the stroma. Embracing it in common with other pelvic viscera are portions of the pelvic fascia. As this lies around the gland it is separated at the sides and particularly in front by the prostatic plexus of veins.

Relations.—The prostate gland lies about one-and-a-half or two inches above the anus. Within the bladder the shape of the gland can be measurably defined even in health. In many diseased conditions the tendency exists for the gland to project within the bladder and to form an obstructive growth which will arrest the flow of urine from the bladder.

The Bloodvessels of the prostate gland.—The arteries are derived from the inferior vesical and middle hæmorrhoidal arteries. An artery may be found running between the capsule and the ileo-vesical reflection of fascia. The prostatic veins open into the prostatic plexus, and are generally seen filled with coagula, and in old persons are occupied here and there by phleboliths. It is from this plexus that the venous hemorrhage in the operation of lithotomy is derived. According to Valentine Mott,[2] the bleeding

[1] Centralbl. f. d. Med. Wissenschaften, No. 22, 1871.

[2] N. Y. Journ. of Med., 1858, 319.

resulting from cutting through the plexus in the operation of lithotomy is slight. Secondary hemorrhage may be, however, alarming in amount in patients of middle age—the veins emitting an enormous quantity of blood.

Variations.—The prostate is rudimentary in instances of unusual development of the masculine uterus. (See Teratology.)

Remarks.—The prostate gland is cut through in the perineal operation for lithotomy. The organ is susceptible of a peculiar hypertrophy which is announced about the forty-fifth year.—Tubercular and gonorrhœal abscesses are not infrequent.

THE PENIS.

The Penis (figs. 3, 4, Plate CVIII.) is the organ of copulation. It is an erectile, symmetrical structure, and accommodates that portion of the urethra which lies in advance of the membranous portion. In the undissected subject, the part which lies in advance of the scrotum and is covered with integument is known as the *pendulous portion*. The *deep portion* of the penis (root, sub-pubic portion) lies in the sub-pubic space.—The skin-covering of the pendulous portion is remarkable for its thinness, for the absence of subcutaneous fat, and for the loose attachments to adjacent structures. The integument serves to cover in the anterior extremity, or glans penis, by a cap-like duplicature (prepuce), the outer surface of which is cutaneous, the inner (where it is applied to the glans) muco-dermic. The layer last-named is held firmly to the body of the penis at a point of constriction (neck of the penis), which is found directly behind the glans, whence it is traceable over the glans to the urethra, with the mucous membrane of which it is continuous.

When erected the penis is subcylindrical in form.—The pendulous and deep portions are composed of three distinct structures, namely, a pair of cavernous bodies (*corpora cavernosa*) and a median spongy body (*corpus spongiosum*).

Each Cavernous Body arises from the inner lip of the descending ramus of the pubis, and a portion of the ascending ramus of the ischium passes forward toward the median line to unite with its fellow of the opposite side at about the level of the top of the sub-pubic arch. Each body is fusiform, though the portion between its origin and union with its fellow is somewhat swollen and constitutes the *crus*. After the union of the crura these bodies, together with the corresponding portion of the spongy body, compose the *body* or *shaft* of the penis.

Both cavernous bodies are abruptly acuminate at the anterior free end, and are received within the posterior concave surface of the glans.

The cavernous bodies, as conjoined, present a faint groove above for the dorsal vein, and beneath a wider groove for the spongy body. Surrounding the cavernous bodies is a dense *sheath* composed of fibrous tissue intermingled with elastic filaments.

The greater portion of the sheath is composed of a layer of longitudinal filaments which surround the cavernous bodies. Beneath this is a second layer, composed of circular filaments. The septum is a partition of similar filaments well developed posteriorly, but presents the appearance of an irregular open network (septum pectiniforme) anteriorly. From the septum numerous fibrous bands (trabeculæ) extend outward, which intersect among themselves, and which define a number of spaces lined with squamous endothelium, constituting the erectile tissue of the cavernous bodies. A number of delicate nerves and unstriated muscle-fibres lie along the trabeculæ. The intervening network is occupied by the terminal twigs of vessels and capillaries.

Bloodvessels.—The arteries of the cavernous body are derived from the internal pudic,—each cavernous body receiving in addition deep branches from the dorsal artery of the penis. The branches and more superficial twigs terminate in delicate spiral arterioles from the extremities of which the capillaries take their origin. These arterioles have received the name of the *helicine arteries* of J. Müller.

The *veins* of the cavernous bodies are tributary to the pudendal plexus and to the internal pudic vein.

Nerves.—The nerves form a plexus within the cavernous bodies, and are derived from the hypogastric plexus.

Lymphatics.—The lymphatics join the hypogastric lymphatic glands.

The Spongy Body is a modified cylindrical figure lying at first in the space between the converging crura of the cavernous bodies, and beyond this point in the groove beneath these conjoined structures. At the extremity of the penis it terminates abruptly in an expanded extremity, the *glans penis*, to receive the ends of the cavernous bodies. The glans penis is obliquely truncated from below upward and backward, and ends in a thickened rounded edge—the *corona glandis*.

The spongy body is swollen behind to constitute the *bulb* which is in contact with the triangular ligament. The spongy body surrounded by the Bulbo-

Cavernosus muscles is contracted between the bulb and the glans penis, and yields at the base of the corona a number of follicular glands (glands of Tyson), which secrete a semi-solid substance, known as *smegma*.—The spongy body resembles the cavernous in essential features. The fibrous investing tissue is weaker than in the former organ, and the trabeculæ less noticeable.

The bulb in the young subject exhibits a slight tendency to become bi-lobed.

Bloodvessels.—The arrangement of the *arteries* of the spongy body is of the same character as that seen in the cavernous bodies. The branches of the internal pudic have sometimes received the names of the bulbo-urethral and the bulbo-cavernosus arteries.

The glans penis receives, in addition to the bulbo-cavernosus artery, a separate branch from the dorsal artery of the penis.

Veins.—The veins of the penis chiefly pass out through the deep parts of the organ, particularly through the bulb of the spongy body and the back part of the cavernous bodies. Others effect exit between the cavernous bodies and the spongy body, and, passing upward along the sides of the organ, join the dorsal vein. The dorsal vein of the penis receives much of its blood from about the anterior portion of the spongy body. Tributary veins to the dorsal vein also pass upward from the sides of the spongy body.

Nerves.—The nerves are derived from the hypogastric plexus, as well as the pudic. The terminal twigs upon the glans bear Pacinian corpuscles.

Lymphatics.—The lymphatics of the spongy body are abundant, and lie beneath the covering of the glans and prepuce, as well as beneath the mucous membrane of the urethra. The superficial vessels are received by the inguinal glands, while the deeper ones empty into the hypogastric ganglia.

Variations.—The glans may be cleft so as to form two distinct portions, the meatus of the urethra appearing at the base of the fissure; the prepuce may be absent or may be congenitally adherent to the glans penis, and the smegma be mechanically retained in the partially obliterated preputial chamber. When the urethra terminates at a point on the under surface of the organ back of the glans penis, the condition known as *hypospadias* is said to exist. Hypospadias should be studied together with malposition of the testicles and with development of the utricle. When the urethra is open above, *epispadias* is said to exist, a condition which should be studied with ectrophy of the bladder. The utricle may be of large size, a condition which is, as a rule, associated with hypospadias.—The utricle may extend a short distance behind the bladder, or it may pass up well into the pelvis and occupy the position of the uterus in the female. The pouch is easily determined by the position of the vasa deferentia, which should open into it. The prostate body in cases of hypospadias is rudimentary.

Remarks. — Owing to the loose connective tissue about the penis the organ is susceptible of great swelling when acutely inflamed. Extravasation of blood may occur in the same position, and even gangrene of the integument ensue.—The integument of the penis is appropriated by swellings and growths originating in the scrotum. Under these conditions the penis appears to be retracted, and almost lost within the contour of the tumefied scrotum.

The cavernous bodies, when rigid by erection, are liable to lesion, especially to "fracture," which is complicated with great extravasation of blood.—Instances are known in which the entire cavernous bodies have sloughed away. Mr. Gay[1] has reported an instance of gangrene of both the cavernous and spongy bodies.—The spongy body retains an intimate association with the urethra. Urethritis when of high grade involves the spongy body; abscess of the spongy body is occasionally noticed as a sequel. From the fact that the spongy body is slightly shorter than the cavernous bodies, the penis when erected is moderately curved. The curve is exaggerated in erections associated with inflammatory stasis and infiltrations within the spongy bodies.

[1] Tr. Path. Soc. Lond., 1878; see also Archiv f. clin. Surg., 1879, 5.

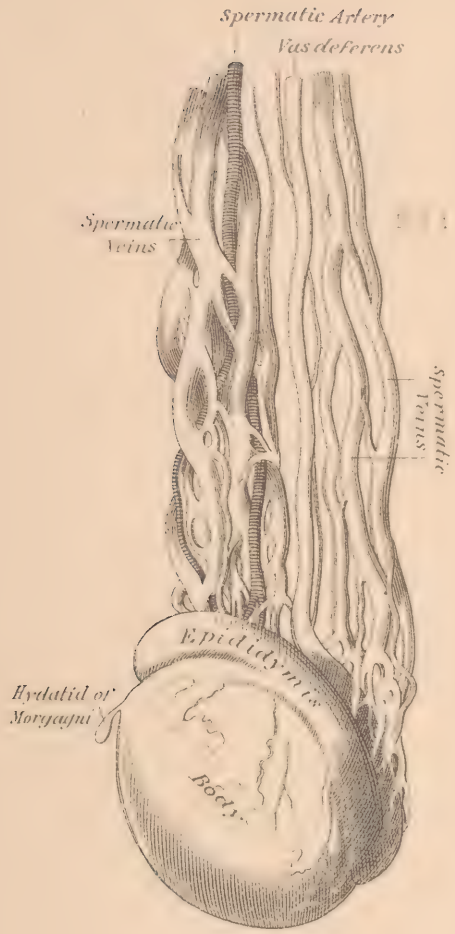
EXPLANATION OF PLATE CVIII.

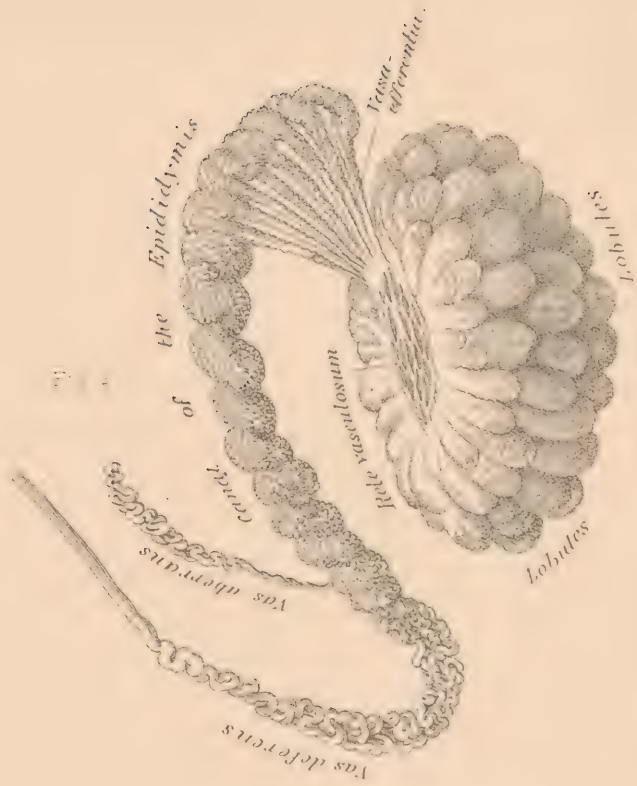
Fig. 1. The testicle with its duct and vessels in position in the spermatic cord.

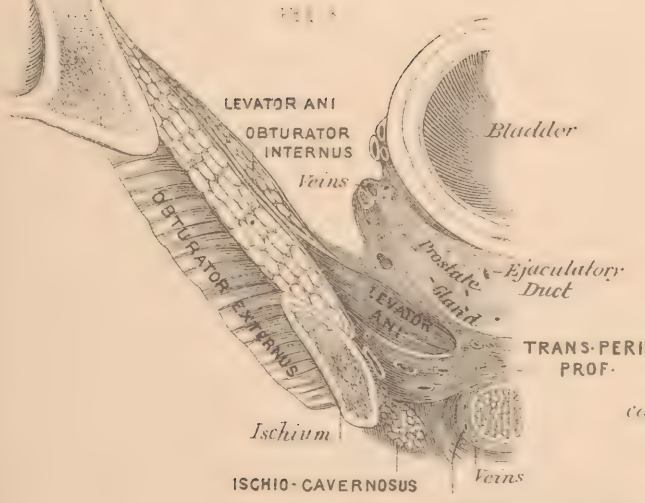
Fig. 2. A diagrammatic representation of the testicle displayed on the plan of injection.

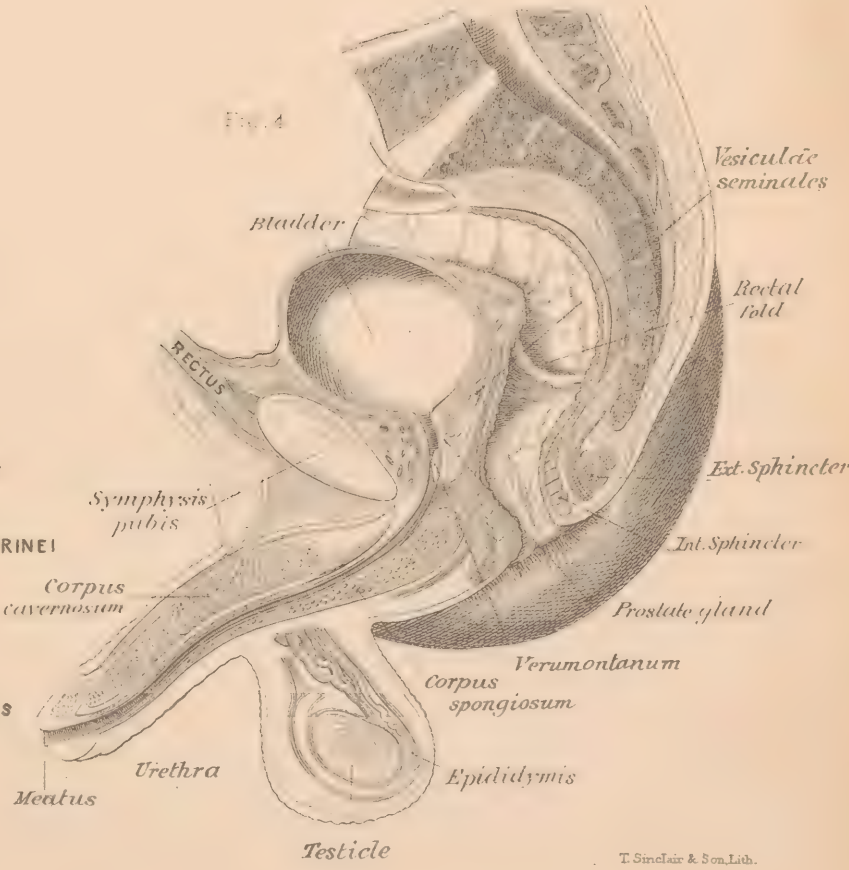
Fig. 3. A sinistro-dextral (frontal) section of the right half of the male perineum.

Fig. 4. An antero-posterior (longitudinal) section of the male pelvis and the organs of generation.









T. Sinclair & Son, Lith.

THE URETHRA OF THE MALE.

The Urethra is that portion of the genito-urinary tract extending from the bladder outward. The internal orifice is known as the internal meatus or vesical orifice; the external orifice as the cutaneous orifice or external meatus.

The Urethra, when the penis is at rest, describes an ∽-like curve; the portion at the right end of the figure corresponds roughly to the pendulous division of the penis, and is known as the *spongy portion* of the urethra; the portion at the left end of the figure represents the *membranous* and *prostatic* portions. The length of the urethra is about six inches, of which the membranous and prostatic portions represent each one inch, the remaining four inches pertaining to the spongy portion, and when the penis is erected it is slightly longer upon its anterior than its posterior surface.

The *prostatic portion* lies between the bladder and the triangular ligament. It measures one-and-an-eighth to one-and-a-half inches in length. It is from one-fourth to one-third of an inch wide at its widest part, and gradually tapers thence to both the anterior and the posterior end. The prostatic portion is surrounded, as the name expresses, by the prostate gland, a layer of longitudinal muscle-fibres alone intervening.

The floor of the prostatic portion of the urethra is marked by a conspicuous elevation called the *veru montanum* (caput gallinaginis, calliculus seminalis, urethral crest), which begins at the base of the bladder and terminates somewhat abruptly at the middle of the prostatic portion. It measures eight to nine lines in length by one-and-a-half lines in height, and is marked in the centre by an oval depression which is one-third to one-half of a line in width, and which constitutes the mouth of the utricle.—The *utricle* (uterus masculinus, sinus pocularis, pouch of Weber) is a flask-shaped chamber which measures two-and-a-half to six lines in length, and from two to three lines wide. The utricle is held to be the homologue of the uterus, and in some animals is large, and is used as a reservoir for spermatic filaments. The lateral margin of the utricle receives the ejaculatory ducts; or the ducts may empty into the depressions at the sides. Surrounding the veru montanum are the orifices of the prostatic follicles.

The *membranous portion* lies between the two layers of the triangular ligament, about one inch below the pubic arch. It is in consequence the least extensible of any of the three portions of the urethra.

It is nine lines in length on the anterior surface, and six in length on the posterior surface. The diameter of the canal at the proximal end of the membranous portion is six lines, and at its distal end five-tenths of a line.

The membranous portion is embraced by the Deep Perinei muscles,[1] and is sometimes known as the cavernous portion.—The circular fibres are well developed.[2] The mucous membrane is plicated, but is without glands.

The *spongy portion* is surrounded by a cavernous submucous layer, which is more abundant at the region of the bulbous portion of the spongy body than elsewhere. This layer is succeeded by a thin layer of circular fibres, which in turn is embraced by the spongy body proper. The spongy portion widens at the region of the bulb to form the *sinus bulbi*, and presents, from that point to a point near the region of the glans penis, a calibre of about one-and-a-half line, when it expands a second time to form the *navicular fossa* beyond which it again contracts to terminate at the meatus urinarius.

The *mucous membrane of the urethra* is covered with columnar epithelium, except a tract about an inch or an inch and a half from the meatus, where it is covered with squamous epithelium. In the tract just named, a number of papillæ are present.

The mucous membrane of the urethra is thin and intimately associated with the submucous tissues. The membrane is plicated when not distended by urine or the seminal fluid.

The spongy portion is furnished with a number of minute racemose glands which have received the name of glands of Littré.

The upper surface of this portion of the canal presents several pockets which open forward and are termed the *lacunæ*. They are found sparse at the side and occasionally beneath.

Cowper's Glands.—The most important appendages to the spongy portion of the urethra are Cowper's glands (sub-urethral glands). These are glands of the racemose type, of about the size of peas, and are placed one on each side of the membranous portion, between the layers of the triangular ligament and

[1] P. 328.

[2] Luschka describes a *Sphincter Urethræ muscle* which is composed, according to Henle, of some irregular fibres of the Deep Transverse Perinei unconnected with the raphé or with the *pubo-ischiatic ligament*. These fasciculi are striated, and should not be confounded with the non-striated true circular fibres.

imbedded among the fibres of the Deep Transverse Perineal muscle. Each of the ducts is an inch long, and passes forward to open into the spongy portion at the bulb. The secretion of Cowper's glands lubricates the urethra with a viscid fluid after micturition. It may also contribute to the seminal fluid.

Remarks.—The urethra can be divided for practical purposes as follows: (*a*) the pendulous portion, (*b*) the membranous portion, (*c*) the prostatic portion.

(*a*) *The pendulous portion.*—The clinical history of this portion is for the most part that of the urethra and also that of the spongy body. The lacunæ are often the sites at which a foreign body or a calculus may lodge. They may be also the seats of localized inflammation.

(*b*) *The membranous portion* of the urethra can be felt through the front wall of the rectum, when an instrument occupies the urethra. In the child the urethra is relatively smaller than it is in the adult. Peri-urethral abscess of this portion of the urethra is a not infrequent sequel of gonorrhœa. The effects of urethral stricture are here most noticeable.

C. E. Isaacs[1] found in a subject examined by him a sac, lined with epithelium resembling that of the urethra and bladder, capable of holding an ounce of fluid, and extending backward and upward from the membranous portion of the urethra between the bladder and the rectum as far as the reflection of the peritoneum. This sac communicated with the cavity of the abdomen by an orifice two lines in width. The peritoneum in the neighborhood was acutely inflamed.

When the bladder is distended, the viscus tends to ascend into the abdominal cavity, while the prostatic and membranous portions of the urethra become stretched and tense. In this condition of the parts, external violence, as blows on the perineum or fracture of the pubic bone, is liable to tear the membranous portion of the urethra transversely, or the incautious introduction of a bougie or catheter (particularly if it be of small calibre) may easily create a false passage. Such a rupture always occurs beneath the symphysis pubis close to the prostate gland. The lining membrane may be divided while the outer coat escapes.

(*c*) *The prostatic portion.*—The clinical interest here relates chiefly to the conditions of the bladder. The prostatic portion is compressed and distorted in hypertrophy of the prostate gland. It is opened by the knife in the perineal operation for lithotomy.

[1] N. Y. Journ. of Med., July, 1858, 1.

J. Hilton[1] has found that a careful study of escaped urethral clots is of value in the diagnosis of urethral affections which are accompanied with hemorrhage.

THE TESTICLE.

The Testicle is the organ which produces the spermatic filaments. It is composed of the testicle proper, or body, and the epididymis. It is a flattened egg-shaped body, whose long axis is directed obliquely upward and outward, and the upper end inclined forward.

The upper end of the testicle is covered with the head of the epididymis, its inner border by the remainder of that structure and the origin of the vas deferens. The remaining surfaces are covered by the tunica vaginalis.

The testicle measures one and-a-half to two inches in length, one in width, one-and-a-quarter antero-posteriorly.[2] It weighs from four to seven drachms.

The main covering of the testicle is called the *tunica albuginea*. It is composed of pure fibrous tissue, and measures half a line in thickness. The tunica albuginea is evenly distributed, but receives a marked accession in thickness beneath the head of the epididymis where it is projected into the parenchyma of the testis. The point of reflection is termed the *mediastinum testis*, and is usually described as though it were a reflection of the tunica albuginea. It is composed, however, of all the structures passing in or out of the testicle; viz.: Tunica albuginea, the pampiniform plexus of veins, and the arteries. It is of a prismatic form, and of a spongy consistence. It is situated at the upper end of the internal border. From its lower portion numerous minute diverging layers of fibrous tissue (trabeculæ) pass into the testis, and serve as imperfect septa between the spaces which lodge the proper gland-substance.

The inner layer of the tunica albuginea is covered with a delicate network of bloodvessels (tunica vasculosa, pia mater testis), which extends along the trabeculæ.

The epididymis is a portion of the excretory apparatus of the testicle which terminates in the vas deferens. It is of an elongated figure, situated at the upper end and internal border of the body of the testicle. The upper end, the head or globus major, is rounded in section, while the lower part, the tail or globus minor, as well as the intermediate portion,

[1] Guy's Hosp. Rep., 1867, 9.

[2] The size of the testicle differs at different times. Slight variation in size Henle attributes to the condition of the connective tissue stroma.

is somewhat prismoidal, the anterior edge being the thinnest. The lower surface of the epididymis is either flat or slightly concave, while the upper surface is convex. It is covered by a membrane analogous to the tunica albuginea, but much thinner.

Structure.—The testicle is composed of a soft parenchyma (pulp of the testicle), which is of a dull white or yellowish color. The parenchyma is composed of a number of lobules, which are variously estimated to be from two hundred to four hundred in number. According to Lauth, they may reach eight hundred and forty. The number of lobules varies in different individuals, and at times a large lobule is composed of two or three smaller ones. Each lobule is of an elongated conical figure, with the base outward and the apex inward. It is supported above and below by the trabeculæ of the tunica albuginea. Each lobule is composed of ramifications of a system of delicate tubes known as the *seminal tubules*. Formerly it was supposed that the lobules were simple but highly convoluted follicles; but it is now thought that they more frequently terminate by anastomosis; some authors denying that they ever end in blind extremities. The lobules are themselves united here and there by anastomotic tubules. The tubules found in a single lobule number from one to three, which finally terminate in a single straight duct. The series of the straight ducts constitute the *vasa recta* of Haller. They are about twenty in number; each possesses a diameter of one-sixtieth to one-seventieth of an inch upward and backward. They place the tunica albuginea toward the inner border of the testicle, and enter a close-meshed network of tubules, termed the *rete testis* (plexus reteformis). It is through the meshes of this network that the bloodvessels pass to and from the gland. The ducts leading from this plexus are termed the *vasa efferentia*. These are from six to twenty in number, and measure from five to eight lines in length. They pass upward and backward, some becoming convoluted to terminate in the epididymis. The thick conical distal end of the convoluted tubes has received the name of *coni vasculosi*.

The minute anatomy of the tubules varies according to the locality. In the body of the testicle they are from $\frac{1}{200}$ to $\frac{1}{160}$ of an inch in diameter, and are lined with layers of delicate but irregular epithelium, which serves as a nidus for the development of spermatic filaments. A layer of flattened, thin cells is found in the rete, which is changed to a columnar epithelium in the vasa efferentia and epididymis, to become again flat at the lower part of the epididymis and throughout the vas deferens.

The connective tissue of the testicle is delicate, but not abundant. In addition it is found that here and there are small aggregations of nucleated cells, limited by the spermatic tubules or by connective tissue.

The Hydatids of the Testicles are two small appendages of the organ, sometimes found in the neighborhood of the globus major of the epididymis. The first of these is called the *hydatid of Morgagni*, a small pear-shaped mass, which contains fluid at its large extremity, but is solid at its junction with the testicle. The second is smaller, and appended to the under surface of the epididymis. It has a more distinct peduncle than the structure first named.

Organ of Giraldés.—The Organ of Giraldés (paradidymis) is in reality composed of two small bodies, the remains of a portion of the Wolffian body, which are lodged in front of the cord above the epididymis. They contain rudiments of tubular structures, ending in blind swollen extremities.

Bloodvessels.—The *arteries* of the testicle are derived from the spermatic artery. The artery of the vas deferens is derived from the inferior vesical.

The *veins* are numerous, and follow the direction of the spermatic cord, and are received in the single spermatic vein, which, on the right side, empties into the vena cava, but on the left is commonly received in the corresponding renal vein.

The lower part of the epididymis and the vas deferens return their blood through a small vein which finally empties into one of the tributaries to the epigastric veins.

Nerves.—The nerves are derived from the internal spermatic plexus and branches of the lumbar plexus.

Lymphatics.—The lymphatics join the lumbar glands.

The descent of the testicle.—A columnar mass pushes inward and upward from the bottom of the scrotal sac, ascending along the vaginal process, which it in part embraces. Cleland has traced within this mass fibres of the External and Internal Oblique muscles, as well as slips of superficial fascia; proof is lacking that these fibres exert traction upon the testicle in the manner taught by Hunter. As the testicle descends within the vaginal process, the fibres of the gubernacular cord (as the columnar mass has been called) appear to be pushed aside while the cord itself is shortened; and by the time the testicle is received within the scrotum, the vaginal process is constricted at the neck from the abdominal portion, and is subsequently separated from the abdominal peritoneum to form the serous sac of the testicle. The pedicle of the gubernacular cord now disappears, and the descent is complete.

THE VAS DEFERENS.

The Vas Deferens is the name given to the canal which unites the epididymis with the ejaculatory duct. It is a cord-like canal, and is remarkable for possessing very thick walls. The vas deferens is

divided into three portions, the scrotal, the pelvic, and the terminal portions.

The *scrotal portion* ascends from the globus minor of the epididymis as a constituent part of the spermatic cord. This portion lies behind the spermatic vessels.

The *pelvic portion* includes the vas deferens as it lies in the abdomen and the pelvis. At the internal abdominal ring the tube is covered with peritoneum, and leaves the spermatic vessels to pass over the iliac vessels. It curves thence downward, crossing the remains of the hypogastric vessels to get to the median side of the ureter, where it lies between the bladder and the rectum, adjacent to the vesiculæ seminales.

The *terminal portion* (ampulla) is slightly expanded before ending in the urethra.

The vas deferens is about twenty-four inches in length, from one to one-and-a-half line in diameter. The walls are composed of three coats, a fibrous, a muscular, and a mucous coat. The inner coat is covered with cylindrical non-ciliated epithelium.

The vas deferens can be felt by rectal palpation.

Variations.—The testicle may be absent in one side, constituting the condition of Monorchia. W. Gruber, who has analyzed three hundred cases of this condition, has determined that the right testicle is more frequently absent than the left, and that the procreative power of the individual is not impaired.

When the testicle is malplaced, as, for example, when lodged in the perineum, it is important to remember that the tunica vaginalis is liable to be continuous with the peritoneum. This is especially apt to be the case in the child. Jas. E. Adams[1] asserts that the liability diminishes as the adult condition is attained. He records a fatal issue of an attempt to restore a malplaced testicle.

The testicle of the right and of the left side may be lodged each in a separate pouch, which represents the half of the scrotum. Various degrees of union of these separate sacs up to the stage of normal development of the scrotum have been recorded. They often coexist with malformation of the penis, especially with hypospadias.

Ludwick[2] describes ten instances in which the testicle was lodged in the perineum; and other cases are mentioned by Humphry.[3]

Remarks.—The testicle may be drawn back into the abdomen. Such retrocession is not uncommon in infancy. In the subjects of congenital inguinal hernia, the testicle may recede at the time the hernial protrusion is restored. In a case reported by H. W. Brock,[4] which terminated fatally by peritonitis, the vas deferens was found looped in the inguinal canal, and the testicle lying in the right iliac region. The vas deferens overlapped and bound down the ascending colon just above the cæcum.—Persistent pain in the testicles, according to Richet,[1] has been found associated with aneurism of the descending aorta and compression of the sympathetic nerve.

[1] Lancet, May 27, 1871, 710.
[2] Dub. Quart. Journ., xix. 76.
[3] Holmes's Sys. of Surg., vol. iv.
[4] New York Med. Journ., 1873, 70.

THE VESICULÆ SEMINALES.

The Vesiculæ Seminales constitute a pair of appendages to the vasa deferentia. Each mass is made up of a convoluted tube, and presents, when in position, an elliptical and somewhat flattened convex figure which is acutely narrowed toward the lower end to be received in the notch of the prostate gland. The mass measures from one-and-a-half to two-and-a-half inches in length, and from four to six lines in width.

The vesiculæ seminales can be felt by palpation through the walls of the rectum.

Variations.—The right and the left mass are often symmetrical. The proportions stated may be exceeded.—There appears to be no correlation between the testicle and the vas deferens. The vas deferens is in no way impaired in subjects in whom the testicle of the corresponding side is absent.

Structure.—The tube when stretched out presents numerous short cæcal branches of various lengths. Sometimes the entire organ is composed of two main diverticuli of about equal length. Each vesicula seminalis is composed of three layers: an outer (fibrous), a middle (muscular), and an inner (mucous) layer. The layer last mentioned is marked by reticulations resembling those seen in the gall-bladder. Some elastic fibres are also present.

Luschka describes a layer of muscular fibres passing across both vesiculæ seminales from side to side, which he denominates the Compressor.

Each vesicula seminalis lies to the outer side of the termination of the vas deferens, between the bladder and the rectum, and above the prostate gland of its own side. It may be intimately held to the upper border of the gland last mentioned in an oblique direction upward and outward. It is in direct contact posteriorly with the fascial covering from the latter organ upward to the *cul-de-sac* of peritoneum termed by Devonvilliers the prostatic peritoneal aponeurosis.

The *ejaculatory duct* is usually described as the common duct resulting from the union of the vas deferens and the termination of the vesiculæ seminalis. It is, however, constructively the continuation

[1] Anat. Chirurgicale, 569.

of the vas deferens after it has received the vesicula seminalis. It is a short tube, measuring one-half to three-quarters of an inch in length, which lies near the base of the prostate gland, and, penetrating the gland, converges toward its fellow of the opposite side, at the same time curving forward and upward to a point near the floor of the prostatic portion of the urethra, when the two tubes abruptly assume a parallel position, having the utricle between them, and empty into the urethra at the side of the veru montanum.—The walls of the ejaculatory duct are thinner than those of the vas deferens which they resemble. The epithelium is of the flat variety, and the muscular coat, according to Henle, is cavernous.

Bloodvessels.—The *arteries* are derived from the inferior vesical and the middle hemorrhoidal.

The *veins* are tributary to the pudendal plexus.

Nerves.—The nerves are derived from the inferior vesical plexus.

Lymphatics.—The lymphatics join the hypogastric gland.

THE COVERINGS OF THE TESTICLE.

The Testicle and the terminal portion of the spermatic cord are lodged in the *scrotum*, a musculo-cutaneous pouch or bag situated at the lower portion of the trunk in front of the perineum. The left testicle being somewhat the larger, hangs a little lower down than the right, and the corresponding half of the scrotum is the more capacious. The median line is marked by a *raphe* which is extended upward upon the under surface of the penis, and is continuous with the perineal raphe. The skin of the scrotum is thin, of a darkish tint, and furnished with numbers of short flattened hairs whose follicles with their associated sebaceous glands are conspicuous through the skin. The scrotal septum (*septum scroti*) extends the entire length of the region, and separates it into halves.

The coverings of the testicle may be arranged for convenience in tabular form as follows:—

Coverings of the Testicle.

Skin.	Integumental (scrotal).
Dartos.	
Intercolumnar Fascia, Cremasteric Fascia, and Cremaster Muscle.	Coverings derived from the abdominal wall.
Infundibuliform Fascia, or Fascia Propria.	General connective tissue about the testicle, and derived from the transversalis fascia and the sub-peritoneal connective tissue.
Tunica Vaginalis.	Serous membrane derived from the peritoneum.

The Dartos is a layer of non-striated muscular fibres which belongs to the tegumental system. When it contracts, it causes the skin to crease. Under the influence of cold the dartos contracts, but relaxes under the influence of warmth.

The Intercolumnar Fascia (Cowper's fascia) extends from the pillars of the external abdominal ring, and passes down over the testicle beneath the dartos.

The Cremaster muscle is composed of a few sparsely distributed loops of muscle-fibres, which, it is believed, originate from the Internal Oblique muscle. Associated with them, and constituting part of the same covering, is a thin layer of connective tissue, the *cremasteric fascia.*

The Fascia Propria (fascia propria of Cooper), infundibuliform fascia, which lies beneath the Cremaster, is a layer of connective tissue which envelops the testicle. It is continuous with the *transversalis fascia* and sub-peritoneal connective tissue at the external abdominal ring.

The Tunica Vaginalis is a serous membrane covering the testicle. Like serous membranes elsewhere, it possesses two layers—a visceral and a parietal. The visceral layer covers the outer aspect of the testicle and epididymis; the parietal layer is in contact with the fascia propria.

In retraction of the testicle the organ loses first the intercolumnar, then the cremasteric coverings, and finally the fascia propria.—Rektorzik[1] has described little club-shaped masses upon the outer covering of the cord. These are suspected to be of the same nature as the Pacchionian bodies of the arachnoid membrane.—Travers has described a hernia lodged in the *processus vaginalis.*—A rudimentary form of dartos has been detected by Sappey in the *labia majora.*—The Cremaster muscle acts with the abdominal muscles, and is contracted in such acts as coughing, crying, etc. It draws the testicle upward and outward.—The dartos raises the testicle vertically.

The Female Organs of Generation.

The account of the Female Organs of Generation will include—

The Ovary.
The Fallopian Tubes.
The Uterus.
The Vagina.
The Vulva.[2]

[1] Sitz. der Wien. Acad., 1857, 23, Bd. p. 134.

[2] The account of the Urethra of the Female is appended to this group for convenience.

THE OVARY.

The Ovary (fig. 1, Plate CIX.) is the egg-producing organ. It is of an almond shape, and is situated between the folds of the broad ligament, but projects upon the surface of the posterior layer. It measures one inch and a half to two inches in length, by three-quarters of an inch in width, and is about one-half to one inch in thickness. Its weight is eighty-seven grains. The ovary is slightly thicker at its outer than at its inner end. It is convex upon its posterior surface, but flat on the anterior, where a depression is seen called the *hilum*. In addition to the support which it receives from the broad ligament, the ovary is connected with the uterus by the ovarian ligament, and to the infundibulum of the Fallopian tube by a process of the fimbriated border.

Structure.—The posterior surface of the ovary is covered with a special epithelium which, instead of being tesselated like that of the adjacent peritoneum, is columnar or prismatic. The ovary is composed of connective tissue containing groups of cells from which are developed the *ova*. The connective tissue has received the name of the *stroma*, and the nests of cells the name of the *Graafian follicles*.

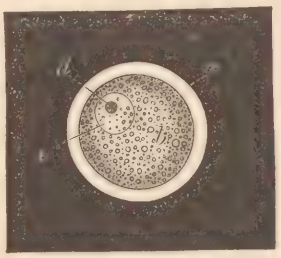
The *stroma* is condensed toward the periphery, where it assumes the appearance of the tunica albuginea of the testis. It is not sharply differentiated from the interior substance, though writers generally speak of the peripheral layer as the *cortex*, and the interior as the *medullary substance*. The medullary substance converges toward the hilum. Intermixed with the foregoing are bloodvessels and nerves, with some elastic tissue and muscular fibres. Those portions of the stroma towards the cortex, containing the ova, and sometimes called *parenchyma*, are largely composed of small spindle-cells disposed in variously interlacing bundles. The nature of these spindle-cells is still disputed; by some writers they are considered to be an imperfectly developed form of muscular tissue, by others but a modified connective tissue.

The primitive *Graafian follicles* are minute rounded masses of cells, from or among which the ova are proliferated or developed. The follicles are arranged in three sets. Those of the peripheral set are the most numerous, are smaller than the others, each follicle having a diameter of one one-hundredth of an inch, and are the most primitive and least developed. Great numbers exist in the ovary of the fœtus.

Those of the set below the foregoing are much fewer in number, but farther developed, and present a diameter ranging from one one-hundredth to one-twentieth of an inch.

The deepest set is composed of yet fewer and larger follicles. It is from these that the ova as a rule mature. They gradually come to the surface and discharge their ova, at the times when the ovary is clasped by the fimbriated extremity of the Fallopian tube. At the time of maturation of each ovum the follicle is limited by a distinct membrane, on the inner side of which are several layers of epithelial cells, the *membrana granulosa;* the mature follicle is usually distended with an albuminous fluid, the *liquor folliculi;* towards the centre of the sac is found the ovum, itself incased in several layers of cells—*discus proligerus*—which are connected by a stalk-like mass

Fig. 192.



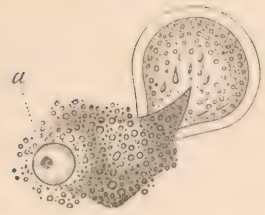
Human ovum magnified 75 diameters. *a*. Vitelline membrane. *b*. Vitellus. *c*. Germinative vesicle. *d*. Germinative spot.

with those lining the follicle. The entire cellular contents of the Graafian follicle—membrana granulosa, discus proligerus, and ovum—are descendants of the cells of the primary *germinal epithelium* of the fœtus.

After the escape of the egg, the cavity of the follicle becomes rapidly filled by a blood-clot, which, although primarily of a reddish-brown color, assumes in time a yellowish color, and has received from this circumstance the name of the *corpus luteum*. This coagulum disappears after the fourth month in the non-pregnant condition, but, should conception occur the *corpus luteum* develops and forms an oval figure, measuring three-fourths of an inch in length by one half of an inch in thickness, and persists during gestation. Between the sixth and the seventh months the corpus luteum contracts, and in the ninth month is greatly reduced in size. It does not entirely disappear, however, until the tenth month.

The *ovum* is a typical cell having a diameter one one-hundred-and-twentieth of an inch. It is inclosed by a distinct limiting membrane or cell-wall, the *zona pellucida*. The interior mass is called the *yelk*, and corresponds to the cell-contents. Floating within the yelk is a *nucleus*, measuring one seven-hundred-and-twentieth of an inch in diameter, which is called the *Graafian or germinal vesicle*, and within this a *nucleo-*

Fig. 193.



Human ovum, ruptured by pressure, showing the vitellus partially expelled, the germinative vesicle with its germinative spot, at *a*, and the smooth fracture of the vitelline membrane.

lus, measuring one three-thousandth of an inch in diameter, which is called the *macula germinativa*, or germinal spot.

Bloodvessels.—The ovary is supplied by the ovarian *arteries*, branches of the internal iliac. The *veins* form a bulb below the hilum which is analogous to the *corpus spongiosum*, and which is sometimes referred to under the name of pampiniform plexus. The ovarian vessels may become varicose, and under pressure may even rupture.

Lymphatics.—The lymphatics join the lumbar glands.

Relations.—The relations of the ovary are subject to great changes, which are more or less determined by the state of the uterus. In pregnancy the ovary is carried up to the side of the abdomen. After delivery it lies in the iliac fossa. In rare instances it has been found in the sac of a femoral or inguinal hernia. Barnes[1] gives the following as conclusions which may be drawn from a study of the *anomalies of relation of the ovaries:* "Such anomalies are frequently the result of inflammatory action. The most common is the adhesion with the Fallopian tube; next in frequency is the adhesion of the ovary, either with or without the tube, to the hinder wall of the uterus, and the neighboring parts of the broad ligament down to the bottom of the recto-vaginal pouch. These adhesions frequently result from puerperal peritonitis at a time when the uterus is above the usual size, filling the pelvic cavity, and when its appendages are thrown back to its posterior surface. Adhesions of the ovary also take place to the sides of the pelvis, to the rectum, to the sigmoid flexure, in consequence of pelvic peritonitis to which anomalous maturation and morbid processes in the ovaries or tubal catarrh has given rise."

The Parovarium.—The parovarium is a group of small tubes varying from twelve to eighteen in number, which are lodged in the broad ligament between the Fallopian tube and the ovary. The tubules slightly converge from above downwards, and are united at their upper ends by a transverse tube, which is longer than the others. A small hydatiform enlargement is often seen in connection with the parovarium. The entire organ measures from two to three lines in width. The tubes are lined with ciliated epithelium. The parovarium is a rudiment of a portion of the Wolffian body, and is homologous with the epididymis of the testis. It is not known to have any practical value. T. Grainger Stewart[1] described a cystic distension of the tubes of the right parovarium. In the same subject the Fallopian tubes terminated in *culs-de-sac.*

Variations.—Supernumerary ovaries are exceedingly rare. Puech[2] and Sinety[3] have recorded examples.

[1] Loc. cit., p. 267.

Remarks.—The ovary may be compressed by external palpation, as a result of which a peculiar pain is experienced. The organ is frequently the seat of neuralgia, which is remarkable for the varied reflexes excited. The ovary may be so far depressed from the position it normally occupies as to be felt by vaginal palpation, when it can be excised through the wall of the vagina. The organ has been repeatedly excised, either for removal of the large cysts or other outgrowths originating in it, or for the relief of obstinate hysterical conditions.

THE FALLOPIAN TUBE.

The Fallopian Tube (fig. 1, Plate CIX.) is the oviduct. It answers pretty accurately to the upper border of the broad ligament, which here holds to the tube a position analogous to that held by the mesentery to the ileum and jejunum. It measures about four inches in length, and is rarely symmetrical, the right being the larger. The Fallopian tube is conveniently divided into three portions:—

(1) The infundibulum.

(2) The free tubal portion.

(3) The interstitial portion, included in the uterine wall.

(1) The *infundibulum* (*morsus dialoli*, or pavilion) is a corolla-like expansion of the tube, designed to embrace the ovary at the time of the escape of the ovum. Its borders are furnished with numbers of rounded or pointed processes, which, from their resemblance to fringe, have been called *fimbriæ.* Some of these processes are arranged upon the sides of others, while the fimbriæ near the borders occasionally unite, causing a lattice-like appearance. One of the fringed processes extends from the ovary to this portion of the infundibulum. At the bottom of the infundibulum is the narrowed opening leading to the *ampulla* (q. v.)

(2) The free tubal portion is widest at its outer end, but contracts toward the uterus. The outer half

[1] Journ. of Anat. and Phys., 1868, 243.

[2] Du Ovaries de leurs anomalies, Paris, 1873, 39.

[3] Comptes Rendus de la Soc. de Biol., ii. 1875, 259.

or two-thirds differs in many particulars from the inner division. It is more movable, somewhat tortuous, and has been called by Henle, from its widened, flask-shape appearance, the *ampulla*.

The inner division, or *isthmus*, is usually about two inches in length and is straight and fixed. Its walls are of great thickness.

(3) The interstitial portion lies within the cornu of the uterus. It measures but 0.04 in. in length, and is straight or slightly concave from below.

The coverings of the Fallopian tubes are three in number, named from within outward as follows:—

The Mucous Membrane.
The Muscular Layer.
The Peritoneal or Serous Layer.

The mucous membrane is furnished with columnar epithelium bearing cilia. These extend upon the fimbriæ, and may be detected even on their outer or peritoneal surface. Within the interstitial portion and isthmus the mucous membrane is smooth, and the diameter of the tube is exceedingly small, scarcely permitting the entrance of a bristle. The opening into the uterus is often found plugged with thick mucus. Within the ampulla the mucous membrane is arranged in longitudinal folds, which present a shaggy appearance, due to great numbers of irregular and often even dendritic villous appendages. In some respects they resemble the *fimbriæ*, by forming lattice-work unions, thus converting portions of the mucous layer into a series of minute canals. When the walls of the ampulla are in apposition, it is probable that the folds are so applied one to another as practically to convert the grooves also into canals.

The muscular layer is composed, for the most part, of circular fibres; a few longitudinal fibres, however, are found lying to the outer side of the foregoing.

The peritoneal or serous membrane is loosely connected to the muscular layer. It does not surround the tube, the lower fourth being in contact with the connective tissue between the two layers of the broad ligament.

Relations.—The most important relation of the Fallopian tubes is the one entertained to the ovary. While the ovary and the Fallopian tube are practically disjunct, the slender attachment so frequently seen extending between the two, as well as the general inclination of the infundibulum, indicates that near approximation, if not direct contact of the two, is readily secured when the fimbriæ are swollen. In most animals the oviduct is continuous with the ovary, but in man and the majority of vertebrates the two are thus structurally distinct.

The broad ligament, while associated in the main with the uterus, under which head it is described, retains the ovary within its folds, and presents a small free lateral border between the infundibulum and the pelvis, and from this fact is called by Henle the *infundibulo-pelvic ligament*. Alterations in the form and relations of this border must ensue upon displacement of the tube.

Variations.—The absence of the Fallopian tube is as a rule associated with absence of the ovary of the corresponding side. According to W. Krause, one or more associated initial openings may exist. The Fallopian tubes very rarely terminate in a cul-de-sac, one inch and a half from the body of the uterus; in which event a fibrous band of the same length as the tube continues thence to the anterior wall of the rectum.[1]

Remarks.—The Fallopian tube may become an ingredient of hernia. Both tubes may become very much enlarged under morbid influences, as for example the retention of the menstrual fluid. Barnes[2] states that blood, mucus, or pus formed in the uterus may thus be driven backward by the contraction of the uterus, distending the tubes, exciting inflammation in them, and perhaps leading to discharge into the peritoneal cavity. In a similar manner fluids injected into the uterus may excite contraction, and this contraction may thence drive the fluid along the tubes if its exit be impeded at the neck, either by flexion, or by the canal being filled too closely by the injecting tube. At the outer end of the tube, catarrhal inflammation often leads to adhesions of

[1] T. Grainger Stewart, Journ. of Anat. and Phys., May, 1866, 243.
[2] Loc. cit., p. 403.

EXPLANATION OF PLATE CIX.

Fig. 1. The ovaries, Fallopian tubes, uterus, and in part the vagina, from in front. The anterior wall of the vagina is removed.

Fig. 2. The external organs of generation in the female.

Fig. 3. The pelvic organs and external organs of generation in the female displayed in an antero-posterior (sagittal) section. The vagina distended in a conventional position.

Fig. 4. The mammary gland—one portion of the gland is represented as dissected to display the lobules and connective-tissue loculi.

Fig 1

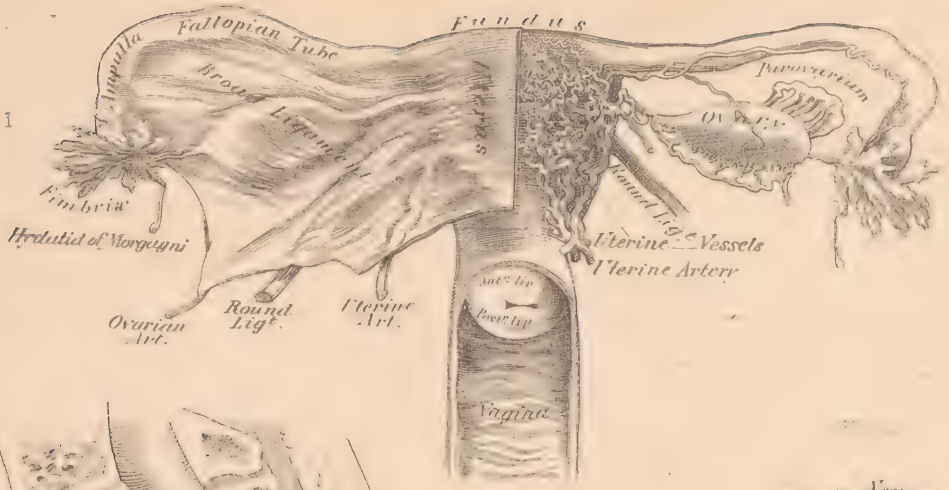
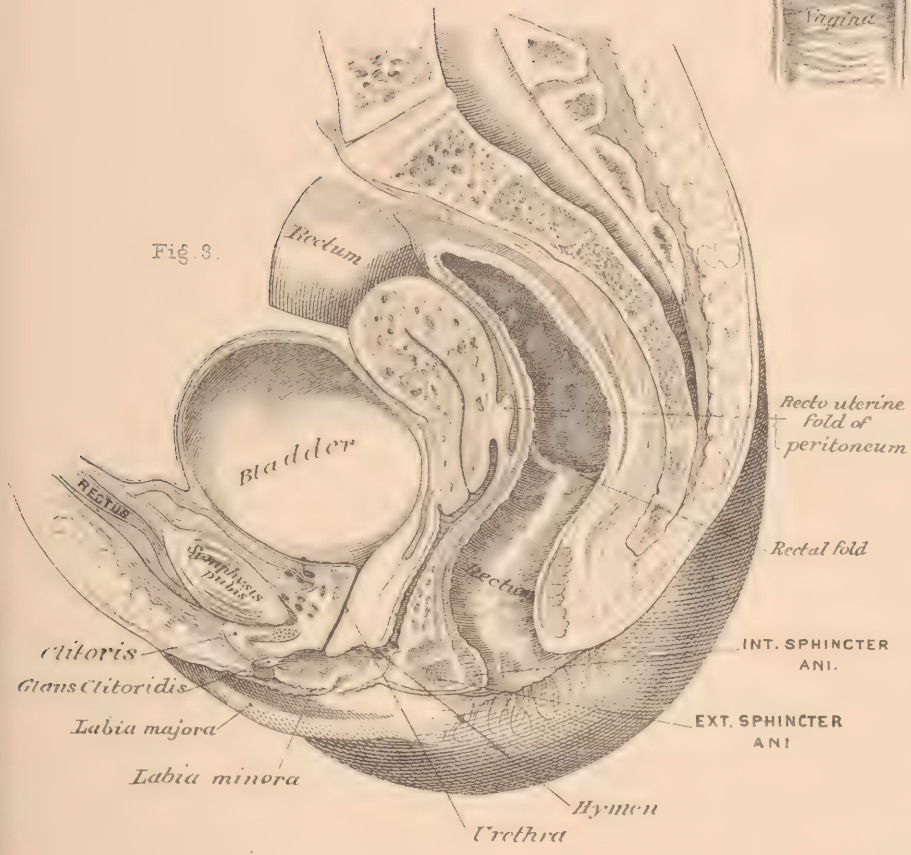


Fig. 3.



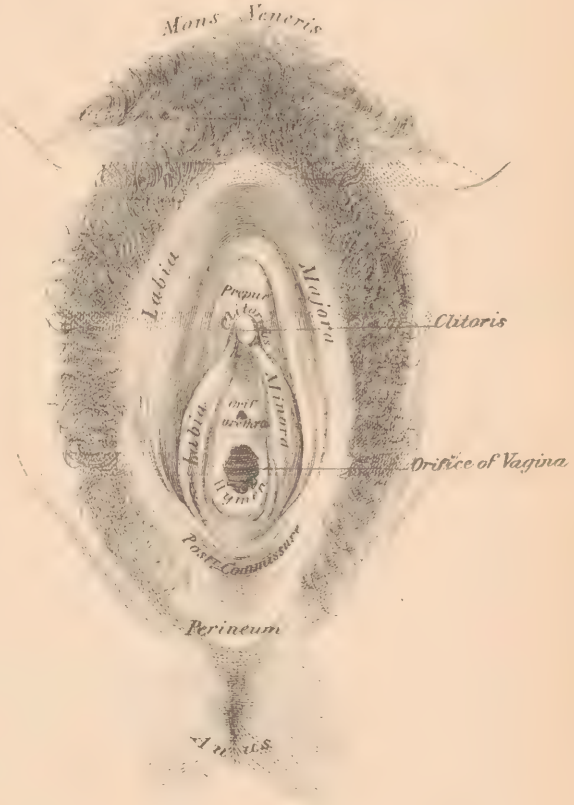
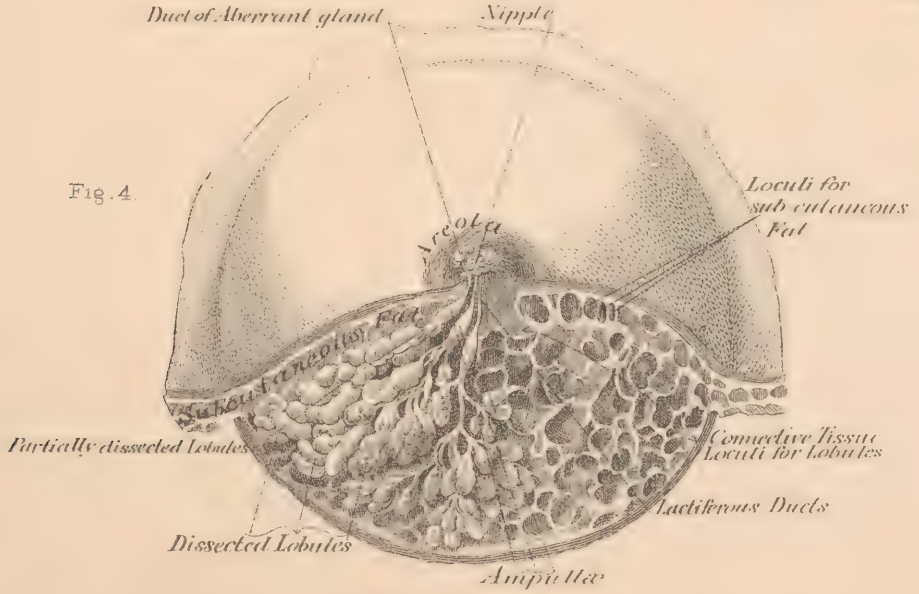


Fig. 4.



T. Sinclair & Son, Lith.

the fimbriæ, and, at the inner end, the swelling of the tube, owing to angular spurs, forms valve-like bendings, which shut off communication with the uterus.

THE UTERUS.

The Uterus (figs. 1 and 2, Plate CIX.) is a hollow muscular sac developed upon the female genital tract between the Fallopian tubes and the vagina. It is the organ of gestation and parturition. Its description will be based upon the organ as seen in the virgin and young adult.

It is situated in the cavity of the true pelvis, behind and above the bladder, in front of the rectum, and above the vagina. It lies in the median line, with a slight inclination from right to left. The uterus is so situated that a line drawn from the upper margin of the symphysis pubis to the lumbo-sacral articulation will intersect the upper margin of the fundus of the uterus. Another line drawn from the lower border of the symphysis pubis to the fourth sacral articulation will intersect the uterus on the lines of the upper limits of the vagina.

The uterus, when studied apart from its attachments, is seen to be of a pyriform figure, which is compressed from before backward. It is slightly concave at the sides, but convex upon its anterior and posterior surfaces, the latter being the more convex of the two. The organ weighs from seven to twelve drachms, and measures, according to Quain, three inches in length, two in breadth at its upper and wider parts, and nearly an inch in thickness.

The uterus is divided into the *fundus*, the *body*, and the *cervix*.

The *fundus* (base) is represented in that part above a line placed below the orifices of the Fallopian tubes. In the virgin the fundus is nearly straight, but in the adult who has borne children it is convex upward.

The body extends from the fundus to the beginning of the neck. It is usually represented as one-half the length of the uterus. Its outer surface is continuous with the neck, but within the interior the two are separated by a constriction called the *isthmus* or *internal os*. Both the fundus and neck are in direct relation with the peritoneum, which embraces them on all sides. Although it is exact to describe the body and fundus separately, the latter term will be selected in describing these portions of the organ as contrasted with the cervix.

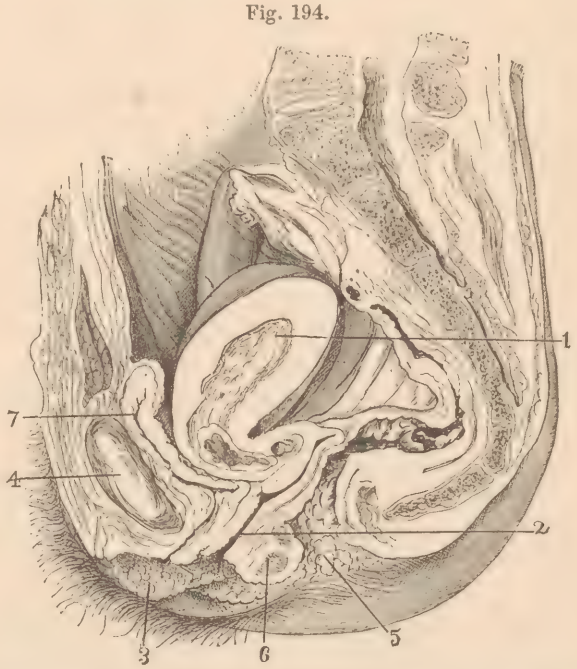
The *cervix* (neck) is the remaining portion. It measures from six to eight lines in length, and is nearly cylindrical in form. Its lower fourth or fifth lies free within the vagina.

"The degree of this projection varies greatly. Thus in some specimens the vaginal portion forms a conical mass projecting an inch and a half into the vagina, while in others there is hardly any variation, the os uteri being almost flush with the vaginal roof."[1] It here forms two lips, an anterior and posterior, about a transverse slit, called the *external os* or *os tincæ*. The anterior lip is the thicker and shorter of the two, but, in consequence of the inclined position of the uterus, lies lower in the vagina.

The upper two-thirds of the neck on its anterior surface are united to the bladder by a thin layer of connective tissue. This relation, since it determines the general position of the uterus, explains many of its deviations in form.

Upon its posterior surface the neck above the vaginal portion is covered with peritoneum. This is less intimately adherent than to the body, and permits a quantity of fatty connective tissue to intervene. At the point immediately above the vaginal embrace, this tissue is pronounced, contains a few veins, and makes a fold in the peritoneum.

Fig. 194.



Antero-posterior (sagittal) section of the pelvic organs of the adult female. The uterus is gravid two months. 1, Uterus; 2, vagina; 3, vulva; 4, symphysis pubis; 5, anus; 6, perineum; 7, bladder.

The sides of the neck and body seen from in front present a concave surface, which accommodates the bloodvessels as they enter and escape from the uterus.

[1] Barnes, loc. cit., p. 233.

The *interior* is smooth, and presents in the body and fundus a triangular appearance, the orifices of the Fallopian tubes and the internal os yielding the angles. In the child-bearing woman the sides of the triangle are more regular than in the virgin, and are less convex.

The cavity of the neck is elliptical, being slightly narrowed at either end. It is circular at the internal os, but somewhat flattened elsewhere. It is marked by the two longitudinal ridges of muscular tissue, one on the front, the other on the hinder surface. Diverging obliquely from these are numbers of lines which cause the entire arrangement to be compared to a fern leaf, and has received from its general plant-like appearance the name of *arbor vitæ*. Henle describes the majority of the lateral rugæ as finally running parallel to the main longitudinal ridge. The two ridges are not exactly apposed according to Barnes, but are adapted side by side. According to Avelin, the thickness of the two sides of the cervix often varies considerably.

The substance of the uterus is of a uniform dark-grayish color, which is best seen in the fundus or body. It is of a spongy character. According to Duncan, under a certain degree of hydraulic pressure, air or liquid may be made to penetrate the entire thickness of the uterine wall. It resolves itself upon careful examination into an intricate association of unstriated muscular fibres. These are arranged from within outward as follows:—

1st. A circular layer continuous with that of the Fallopian tubes. It consists at the fundus of sphincter-like groups about the orifices of the tubes, and, lower down, of bands embracing the cavity of the uterus at low angles of intersection, but becomes circular at the lower end of the body to form the *internal os* or *isthmus*.

2d. Variously placed oblique bands, which tend to surround the uterine vessels.

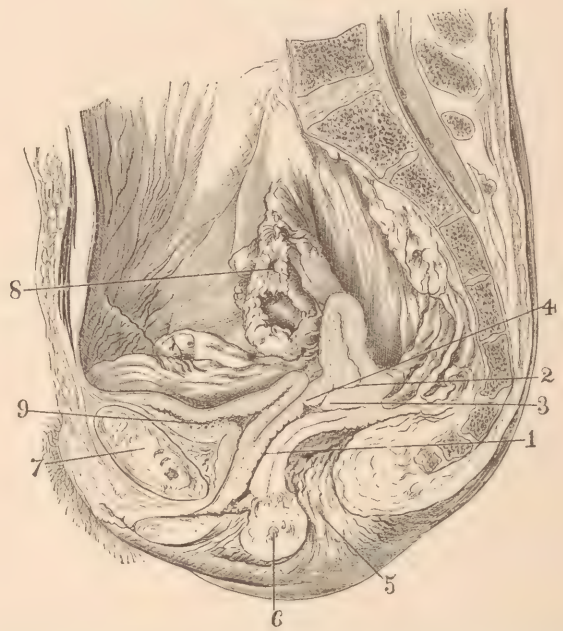
3d. Longitudinal bands, which are for the most part situated upon the posterior surface.

The ligaments of the uterus contain muscular fibre, which is continuous with that of the body of the uterus.

The *mucous membrane* in the body is thin and inconspicuous, but when carefully examined it is seen to be composed of a delicate basement membrane and columnar epithelial cells, which are furnished with cilia. Numerous minute glandular follicles beset the general internal surface of the uterine body and fundus, the orifices of which cause the mucous membrane to appear minutely punctate. These follicles are lined with a cubical, non-ciliated epithelium.

The mucous membrane of the neck differs markedly from that of the body in being of a grayish or rosy-white color, and in being much thicker. The entire surface is covered with squamous epithelium, and the lower third is furnished with villi. The glands of

Fig. 195.



Antero-posterior (sagittal) section of the pelvic organs of a virgin. 1, Vagina; 2, uterus; 3, posterior lip; 4, anterior lip; 5, anus; 6, perineum; 7, symphysis pubis; 8, fimbriated extremity of the Fallopian tube.

the cervix resemble those of the body, but yield a clear tenacious secretion which occupies the os. The *ovula Nobothi* are pellucid cyst-like bodies within the mucous membrane. They are held to be the result of distension of certain of the follicles.

The peritoneal investment of the fundus and body is complete, while that of the neck is restricted to the upper portion only. Not only is this the case, but the character of the investment differs, since in the former the membrane is directly united with the uterus, while in the latter some connective tissue intervenes. Hence while rupture of the body of the uterus induces hemorrhage in the abdominal cavity, a similar lesion of the cervix rarely does so. Indeed, the neck may be said to be surrounded by connective tissue, which is continuous with the connective tissue of the pelvis. It is distinctly traceable, according to Pansch, in the vesico-vaginal and recto-vaginal septa to a greater distance than has hitherto been supposed.

The peritoneum is more firmly united around the body on the posterior than on the anterior surface, while at the lower part, where it passes to form the broad ligament, it is looser.

At the point where the peritoneum is reflected from the neck of the uterus to the rectum and iliac fossa, a decided fold is seen containing connective tissue, fat, and bloodvessels. The contents of the fold communicates inferiorly with the pelvic connective tissue. The same connection is true of the anterior surface of the neck, which permits the creasing of its peritoneum in the anterior inclination of the body. Hence is explained the pronounced rim of indurated tissue which lies round the os uteri in some forms of pelvic cellulitis.[1]

The Ligaments of the Uterus. The ligaments of the uterus include all those symmetrical folds of peritoneum and of fibrous tissue which extend from the uterus to adjacent structures. They are five in number, as follows:—

The Broad Ligament.
The Round Ligament.
The Ovarian Ligament.
The Utero-Sacral Ligament.
The Utero Vesical Ligament.

The *Broad Ligament* extends from the sides of the uterus to the sides of the pelvis. It is composed of two folds of peritoneum continuous with those inclosing the uterus. It obscures the lateral margins, and is nearly on the same plane with the anterior surface of the body of the uterus, thus permitting the posterior surface to project backward.

The upper border of the broad ligament receives the Fallopian tubes within, while below, it is reflected to enter into the floor of the pelvic cavity.

The Round Ligaments arise from the fundus of the uterus, a little in front of and below the Fallopian tubes. Each ligament passes forward as a rounded cord to enter the internal abdominal ring through which it passes to be lost upon the structure of the abdominal wall near the symphysis pubis. This extraordinary relation of a viscus thus holding structural relations to the superficies of the trunk is explained by Rainey,[2] who traces within the round ligament fasciculi of striped muscular fibre which are derived from the abdominal muscles.

The canal conducting the round ligament through the external abdominal ring is called the *canal of Nuck*. It is pervious, as a rule, only in the young.

The *Ovarian Ligaments* are two rounded fibrous cords containing muscle, which extend from the uterus to the ovary.

The *Utero-Sacral Ligaments* are two folds of peritoneum extending from the postero-lateral border of the uterus at the beginning of the neck to the sacrum. They define the pouch of Douglas. In a normal condition, the walls of this sac are in apposition. Great importance is assigned by Pansch to these ligaments. He asserts that their traction is nearly vertically upward, and that they not only tend to tilt the uterus forward, but that they pull the posterior wall of the vagina upward, thus accounting for the post-cervical vaginal pouch.

The *Utero-Vesical Ligaments* pass from the upper portion of the cervix of the uterus to the symphysis pubis. They define laterally the utero-vesical pouch, a shallow receptacle relatively of slight importance.

The last two ligaments, by reason of the muscular tissue they contain, exercise more than a passive function in sustaining the uterus in position. Malgaigne assigns special importance to the utero-sacral ligaments. According to this writer, decided falling of the uterus follows upon their division.

The pouch of Douglas is the most dependent of the pouches formed by the ligaments. Hence collections of fluid in the abdominal cavity will gravitate to this pocket. Marion Sims has suggested puncture of this cul-de-sac from the vagina, in order to secure an efficient outlet for such fluids as accrue after operations upon the peritoneal cavity, and more especially after ovariotomy.

When the relations of the uterus and ovaries and Fallopian tubes to the sac are remembered, it will be readily seen that blood escaping from these organs will collect in the pouch. Barnes thus assigns pelvic hæmatocele to it, and believes that blood appearing within the utero-vesical pouch would soon pass thence to the larger posterior pouch of Douglas.

Relations.—The relations of the uterus are complex by reason of the extreme mobility of the organ, and its changes in size and form in gestation. The following present the leading features of these relations:—

(1) As a primary fact, it may be stated that the uterus is composed of two portions—the body and the neck, which are in some degree physiologically distinct and have separate relations. The body is held in position by the broad ligaments (associated with a few muscular fasciculi distributed therein) and the uterine bloodvessels. The cervix is held in position by the posterior wall of the bladder and the utero-sacral and utero-vesical ligaments.—The body of the uterus is *suspended;* the cervix is in part only suspended (namely, at the point of vesical contact and by the antero-posterior ligaments), and is in great part *supported* by the vagina.—The entire uterus, according to D. Berry Hart,[1] is supported by the structures of the pelvic floor rather than by the so-

[1] Barnes, p. 574, fig. 99.

[2] Trans. Phil. Soc., 1850.

[1] The Surgical Anatomy of the Female Pelvic Floor, 24.

called ligaments.—The body and cervix also differ with respect to the peritoneum. The necessities of the growth of the pregnant uterus require *loose* but direct attachments laterally with the broad ligament, while the peritoneum is only indirectly related to the cervix uteri.

(2) In pregnancy the longitudinal axis of the body of the uterus inclines slightly to the left (a tendency seen even in the virgin state), at the same time that it is inclined upward and forward, perpendicularly to the plane of the superior pelvic strait. Thus it will be seen that the longitudinal axis is not a straight, but a curved line, having its concavity directed forward. According to Kohlrausch, the axis of the vaginal portion of the uterus at the time of menstruation is concave backward, thus making the line sigmoid.—The junction of the body with the cervix, it will be recalled, is marked by the isthmus in the interior, and by a creasing of the peritoneum on the anterior portion of the periphery.—A moderate degree of anteflexion is normal.—The position of the uterus forms an obtuse angle with that of the vagina. Hence the lower end of the uterus is tilted against the posterior wall of the passage last named.

Bloodvessels.—The *arteries* are supplied by the uterine artery, the ovarian artery, and a small branch of the epigastric artery. The *veins* are tributary to the uterine plexus of veins (utero-vaginal plexus). A portion of the blood is returned by the ovarian veins.

Nerves.—The nerves are derived from the uterine plexus of nerves.

Lymphatics.—The lymphatics join the glands (hypogastric glands) situated about the branches of the internal iliac artery.[1]

Variations.—The uterus may be absent, the Fallopian tubes uniting in a transverse band of muscle tissue, in the position of the normal uterus. The organ may be directly continuous with the vagina without the intervention of the os.—The organ may be composed of two long fusiform chambers, uniting in a short and imperfect body (*uterus bipartitis*), as in the mammals generally; when this disposition is but faintly expressed, the uterus is said to be *arcuated;* when pronounced, yet the two horns united by the matrix, the uterus is said to be *anvil-shaped* or *incudiform;* when one horn is alone developed, it is said to possess a *single horn*, and to constitute the variety of *uterus unicornis.*

When the uterus is of normal shape, but the cavity divided in part by a septum extending from the fundus, the organ is said to be *subseptate*, and to constitute the variety of *uterus subseptus;* when the septum above mentioned is complete, the organ is said to be *septate*, and to form the variety *uterus septus* or *uterus bi-locularis.*—The uterus and vagina may be rarely duplicate throughout, while two ovaries, two Fallopian tubes, and two round ligaments exist as in the normal state.

The malformation known as the two-horned or bifid uterus consists of the angles of conjunction of the fundus with the body being greatly exaggerated. This occurs at the expense of the fundus, which, under such conditions, never develops. The circular muscular fibres surrounding the orifices of the Fallopian tube are thus separated by an open space. The condition is normal in mammalia below the man-like apes.

Commonly limited to the body, the condition may extend to the cervix, but rarely reaches the vagina. Decès describes and figures a bifid uterus, one horn of which rupturing, from retained menstrual fluid, induced fatal peritonitis. Should pregnancy occur in one of two horns of a uterus whose general development is imperfect, a class of symptoms may arise closely resembling those of tubal pregnancy. The bicornuate uterus retains the embryo in one of its cavities, the pregnancy usually advancing normally to term. In studying specimens of the kind the observer is enabled to discriminate between it and a tubal gestation by the position of the round ligament. If it lies to the *lateral* side of the sac the fœtus has been retained in the horn of the uterus; if, on the other hand, the ligaments lie to the *median* side, the fœtus has been retained in the Fallopian tube.

Remarks.—The uterus is so mobile that it can be thrown forward by a distended rectum, backward by a distended bladder, or it can be brought down to the plane of the vulvar outlet by gentle traction, a position favorable for some practical purposes, such as operations upon the cervix uteri.—The organ may be forced down by its own weight, constituting *prolapsus uteri*, as is commonly the case, or it may actually form a hernial projection, forming the so-called hysterocele. It has been found as one of the contents of a femoral or inguinal hernial sac, and may be forced up by pressure from below, or deflected from side to side, or from before backward. In marked retroversion the os may actually compress the urethra, as in anteversion, or it may lie toward the sacrum.—The separate physiological and mechanical value of the body and cervix will often express itself in morbid conditions. Thus the body, being, it may be, imperfectly involuted from the proportions of gestation, may sag forward or backward. Tumors may so press upon the organ as to attenuate the union between the body and the cervix. It may be squeezed between an hæmatocele in Douglas's pouch and the bladder. Or a distended bladder may throw it toward the sacrum. The last-mentioned fact is one of great practical importance when it is desired to examine the position of the body of the uterus through the abdominal wall. The previous complete removal of the contents of the bladder facilitates the examination.

[1] See J. Hoggan and F. E. Hoggan, Journ. of Anat. and Physiol., 1882, xvi. 51.

Among other patho-anatomical relations may be mentioned the possibility of the occurrence of abscess in the connective tissue between the bladder and the uterus, a fact well authenticated by Barnes, and for which we may be prepared when, as Kohlrausch informs us, the union between the two organs is such that it is difficult to identify the tissue as distinct from the muscular fibre of the two organs.—The round ligament is vascular, and is especially rich in veins. These may become varicose, and according to Cruveilhier may simulate hernia. The canal of Nuck is rarely persistent, when it may serve for the easy descent of a hernial protrusion.—W. L. Atlee[1] narrates an instance of an enormous collection of retained menstrual fluid in the posterior division of a bi-cornuate uterus.

THE VAGINA.

The Vagina[2] (figs. 1 and 3, Plate CIX.; figs. 193, 194) is a musculo-membranous canal extending from the uterus to the vulva. It is narrowed below, and joins the vulva by a vertical slit-like orifice. It receives above the lower third of the neck of the uterus. It is slightly curved from before backward, but preserves in the main the axis of the true pelvis. When its relations are undisturbed the length of the vagina is not greater than two-and-a-half inches. It can, however, easily be extended to four inches, which is usually given as the normal length. The posterior wall is found to be five lines longer than the anterior. The walls of the vagina are for the most part in apposition, but can without undue violence be separated one inch, which may be said to be the diameter of the parts in the virgin.

At the level of the hymen and under the influence of the Sphincter Vaginæ the lower portion of the vagina is the narrowest; the upper part (fornix vaginæ) is maintained in a nearly cylindrical form by the neck of the uterus; the form of the intermediate portion is dependent upon the condition of the bladder and of the rectum, but may be said to be flattened from before backward.

The inner surface of the vagina presents two longitudinal elevations—one on the anterior, the other on the posterior surface—termed the *columns*. Associated with each column are a number of *rugæ*, arranged transversely to a median longitudinal ridge; they recall the roughened elevations on the hard palate. When a transverse section of the vagina is made the two columns are seen touching. This appearance is much modified by child-birth. The columns and rugæ become faint above, and may entirely disappear. The rugæ are more persistent on the anterior than on the posterior wall, and are always constant toward the lower part of the anterior column. The fact last mentioned is of practical importance, since the column forms a prominent swelling which, by its relation to the posterior wall of the vagina, closes the vestibule posteriorly. The constancy of the position of the anterior column is of great value in introducing the catheter by serving as a guide to the position of the urethral orifice.

Directly in front of the rugous swelling just described is the *hymen*. This is a crescentic fold of mucous membrane jutting forward into the lumen of the vagina from the posterior and lateral walls. It is thicker at the attached than at the free border. The hymen, as a rule, indicates virginity. It appears early in the fœtus and persists until coitus; after which act the remains of the hymen are seen as fimbriæ or scar-like nodules, termed the *carunculæ myrtiformes*.

The foregoing description answers to the average condition of the parts. The hymen, it is necessary to state, is subject to great variation. The importance of variation both in practical medicine and in medico-legal studies has led to their careful consideration. The existing state of knowledge on the subject may be epitomized as follows:—

(1) The hymen may not be ruptured in coitus, and after the act may recover its virgin appearance. (2) The opening may be torn or dilated by the finger or instruments. (3) It may be imperforate, causing retention of the menstrual fluid.

Luschka has described as among the unusual variations of the hymen a fimbriated form; and Hyrtl mentions the rare occurrence of a hymen furnished with more than one opening.

The bulb of the vagina.—Under this name are included two erectile organs which are situated upon the lateral walls near the inferior orifice of the vagina, and which are believed to be homologous with the spongy body of the male. Each portion is elongated and leech-like in form, the inner surface concave, the outer surface convex, and the whole embraced by the Sphincter Vaginæ muscle.

Relations.—The vagina is placed between the bladder and the rectum. The anterior wall is thus described as entering into the *vesico-vaginal septum*, and the posterior entering into the *recto-vaginal septum*. The pelvic connective

[1] Ovarian Tumors, 301.

[2] The figures on Plate CIX. represent the vagina distended, and may be said to represent the conventional view. The actual disposition of parts, as seen in carefully made sections, varies greatly in different subjects; two views are given in figs. 193 and 194, from D. B. Hart.

tissue is continuous with that round the neck of the uterus, and thence can be traced down a short distance about the vaginal wall. In consequence of this arrangement the bladder and rectum are less intimately associated with each other than with the lower part of the vagina.

The anterior wall of the vagina is continuous below with that of the urethra, hence the name *urethro-vaginal septum* given to this region. This septum is thickest at its lowest part, where it measures five-and-a-half lines.

The posterior wall of the vagina enters for the most part into the recto-vaginal septum. As is the case with the vesico-vaginal, the lower part of this septum is the thicker. The upper fifth of the posterior wall is in contact with the peritoneum at the bottom of Douglas's pouch. This is a most important relation, and should also be remembered in connection with the course of the ureters. The ureters lie about four lines from the vagina, and between it and the Levator Ani muscles, at the upper portion of the canal, to which they are joined by connective tissue. Communication of the ureter with the vagina is possible, as shown by W. A. Freund.[1]

Structure.—The vagina is composed of three coverings, the mucous membrane, muscular tissue, and dense connective tissue. These are not arranged in well-defined layers, but are placed in the order named from within outward.

The mucous membrane is covered by a thick squamous epithelium. The papillæ are large, but concealed by the epithelium. The glands of the vagina are indifferently developed. A few sparse racemose glands are named by Luschka as occurring at the orifice and at the upper portion of the vagina. The remaining glands are of the closed variety, and are insignificant. Some writers describe mucous follicles in the vaginal vault.

The muscular fibres of the vagina are of two kinds, longitudinal and circular. The latter are the more external. Interspersed among the fibres is a quantity of connective tissue (rich in elastic fibres), which extends beyond the muscular fibres, and serves to separate the vagina from the bladder and rectum respectively.

As already mentioned, the orifice of the vagina is surrounded by the Sphincter Vaginæ, a thin bundle of striped muscular fibres derived from the tegumental layer of the perineum.

Variations.—The vagina may be absent, narrowed, or may exist as a *cul-de-sac* opening on the perineum in the normal manner. The hymen may be imperforate and of great thickness. A septum may extend either wholly or in part along the vagina, thus converting the single passage into two. The hymen may be present in both passages. Very infrequently two uteri may be found in conjunction with the vaginæ, but commonly the septum ends at a point below the os.

The vagina, together with the bladder, may form a uro-genital sinus, into which the rectum opens, and thus form a chamber which, in the new-born subject, will be found filled with meconium. Atresia of the rectum, the vagina, and the bladder may coexist with Sympodius (*q. v.*).

Remarks.—In women who have borne children the vagina is bag-like, and wider than in the virgin. The contracted orifice maintains a condition favorable to the retention of clots in uterine hemorrhage, as well as of menstrual fluid.

The vagina is susceptible of inversion from the dragging downward of a displaced uterus, and of distension from the descent of the fœtus in child-birth.

Its walls may be involved in penetrating wounds of the vulva and the perineum. Such wounds, if extensive, may perforate both walls and involve the bladder or the rectum, and possibly the peritoneum (see Fig. 194).

In the genu-pectoral position, the vagina becomes distended with air, and the examination of its walls is greatly facilitated.

The posterior wall of the vagina is tense in parturition, when it may be ruptured by injudicious pressure from instruments. Instances have been recorded of extensive lesion of the vagina under the conditions named with protrusion of loops of the sigmoid flexure.

For clinical purposes the vagina may be divided by three planes which intersect the passage at right angles to the longitudinal axis: (1) The parts on and just above the level of the hymen include that portion of the vagina which answers to the urethra as it lies *below* the symphysis pubis. The clinical relations of this portion are with the vestibule and the so-called true perineum. (2) The parts answering to the portion of the urethra lying *behind* the symphysis pubis. Here the clinical relations are with the urethra in front and the rectum behind. (3) The parts answering to the vaginal vault; these relate to the peritoneum both front and back in contracted states of the bladder and the rectum, and with the bladder-wall chiefly in front in distended states of the bladder. It is in this section that peritoneal involvement from vaginal lesion can occur, and that the ovary can be excised.

THE VULVA.

The Vulva (fig. 3, Plate CIX.; figs. 194, 195) includes the external organs of generation.

[1] Klin. Beiträge zur Gynäkologie, Heft i. 1862, 59.

The parts so included are:—

The Mons Veneris.
The Labia Majora.
The Labia Minora.
The Clitoris.
The Glands of Bartholin.

The bulk of the Mons Veneris is due to a cushion of fat covering the pubis. It is continuous above with the skin of the abdomen, and below with the labia majora.

The Labia Majora is the name given to a pair of divergent folds of skin and inclosed fatty tissue forming the lateral boundary of the vulva. These folds are thicker above than below, and are commonly covered on the outer side for the most part with a sparse growth of hair. The lower ends terminate at about an inch in advance of the anus at a small transverse fold termed the *commissure*, which is at once the posterior boundary of the vulva and the anterior boundary of the female perineum.

Directly in front of the commissure lies a shallow depression, which has received the name of the *fossa navicularis*. In advance of this is a delicate transverse fold known as the *fourchette*.

The Labia Minora (nymphæ) are two thin mucodermic folds, lying directly within the labia majora. They arise from the sides of the prominence of the clitoris with the integument covering which they are continuous. They terminate below at the sides of the orifice of the vagina.

Luschka describes the nymphæ as forming a small transverse fold posteriorly; this, in his opinion, is the *fourchette*, which would thus be removed from the labia majora. See, also, *infra*, in quotation from M. Duncan.

The *vestibule* is a term restricted to that portion of the vulva bounded laterally by the nymphæ, above by the clitoris, behind by the fourchette, and within and behind by the upper margin of the orifice of the vagina, by the hymen, or by its remains.

The Clitoris is a symmetrical organ representing a rudimentary penis. It is composed of a pair of cavernous bodies each of which arises from the descending ramus of the pubis and the ascending ramus of the ischium. These bodies are held together anteriorly by a fibrous membrane, analogous to a rudimentary *septum pectiniforme*. The clitoris measures one-and-a-half inch in length, and can be felt beneath the skin covering. The free end of the organ lies in a cap-like fold of skin which has been compared to the prepuce, and the inclosed part to the glans penis. No such structure, however, as a glans exists in the clitoris. It consists only of the cavernous bodies.

The Glands of Bartholin (vulvo-vaginal glands, glands of Duverney), are two in number.

Each is a racemose gland about a third to half an inch in diameter, and of a rounded or reniform outline, and is yellowish-red in color. It is situated between the cellular tissue of the vaginal wall and the Constrictor muscle of the vagina, and behind the lower part of the spongy body. The duct, about half an inch in length, passes forward to open between the nymphæ and the hymen.

The glands secrete a mucoid fluid, and are most active during the child-bearing period.

The mucous membrane of the vulva is smooth, pink in color, and covered with squamous epithelium. It possesses numerous simple racemose gland follicles, on the inner side of the nymphæ and about the urethral orifice. Sebaceous glands are found beneath the fold of skin at the free end of the clitoris, on the outer side of the nymphæ, and upon the labia majora. The papillæ of the mucous surface are as a rule well developed, and are abundant upon the inner surfaces of the nymphæ, where they assist in the sexual impression.

Bloodvessels.—The *arteries* of the vulva are derived for the most part from branches of the internal pudic; a superficial branch is derived from the superficial external branch of the pudic for the outer parts. The *veins* communicate with the *bulb*, with the vaginal plexus, and thence for the most part with the obturator veins. Some of the superficial blood returns by the external pudic vein to the femoral vein.

Nerves.—The *nerves* are branches of the ilio-inguinal and genito-crural nerves of the lumbar plexus.

Lymphatics.—The lymphatics join the inguinal and the internal iliac glands.

Remarks.—The labia majora, receiving as they do both bloodvessels and nerves from distinct sources, may be involved in common with the parts relating to the lower limbs or with the pelvic organs. The engorgement of the lymphatics of the lower extremity, as in "milk-leg," may involve the vulvar lymphatics, while epithelioma of the labia majora will involve by extension the lymphatics of the pelvis.—The clinical relations of the nymphæ and the clitoris are entirely with the pelvis.

The peculiarities of the vulvar and vaginal orifices before and after the birth of a child are well described by M. Duncan. Since these conditions have exact clinical values, the remarks of this writer are copied in full.

"In the primipara the outer or larger margin of

the hymen, or its margin of insertion, is the exact limit of the vagina at the margin of the vaginal orifice. Close to the anterior or upper margin of the orifice is the urethra. At the sides of the orifice are the lower ends of the nymphæ, but there is quite a considerable interval between them and the vaginal orifice. Remote from the nymphæ, and closely adjoining the posterior margin of the vaginal orifice, are the openings of the glands of Duverney (glands of Bartholin). These openings are in the fossa navicularis. The last-named fossa lies between the orifice of the vagina and the commissure or anterior marginal portion of the perineum. The labia majora are not united posteriorly, but form separate pieces parallel to and touching one another, at the same time they end somewhat abruptly."

The effect of the first birth upon the above arrangement is the following:—

"The hymen is partially or completely destroyed. If the orifices of the ducts of Duverney's glands are not discernible, it is impossible to say exactly where any part of the vaginal orifice is, except when distinct remains of the hymen are seen. The distinction of the fourchette or posterior margin of the vulvar outlet from the margin of the vaginal orifice cannot now be made with any exactness. The labia majora have shrivelled, and the position of their projecting posterior parts is ill defined. If in a multipara the head is obstructed by the undilatability of the orifice of exit from the woman's body, then it cannot be said that the vaginal orifice is rigid and obstructing, for that part is not recognizable. It is the vulvar outlet that by its undilatability impedes progress."

THE URETHRA IN THE FEMALE.

The Female Urethra[1] (figs. 2, 3, Plate CIX.; figs. 192, 193) opens within the vestibule about midway between the clitoris and the hymen. The urethra is a small slit-like passage about one-and-a-half inch long, and presents a diameter of three to four lines; it is somewhat wider toward the bladder. Its mucous membrane is of a whitish color, and is thrown into a number of longitudinal plications. The membrane receives the orifices of a number of muciparous follicles which lie for the most part in the sulci between the folds. The minute anatomy of the female urethra reveals a structure recalling that of the male urethra. Thus, it possesses a scaly epithelium becoming tessellated toward the bladder. Beyond this is a layer rich in veins, and beyond this between the layers of the triangular ligament it is embraced by the Compressor Urethræ muscle. It differs from the male canal, however, by the increased quantity of elastic tissue.

M. Merle[1] states that, owing to the subjacent connective tissue being lax in the female, the urethra is prone to prolapsus in inflammatory engorgement such as is seen in gonorrhœa. Thus, this condition is based upon an anatomical relation distinguishing the female urethra.

According to J. Englisch,[2] the mucous membrane of the urethra exhibits larger glands upon the posterior and lateral walls than elsewhere. These glands are liable to cystic distension in the fœtus, leading at times to prenatal occlusion of the urethra, and retention of urine. The etiology of the cysts "lies in the peculiar disposition manifested in the last months of fœtal life to the adhesion of superficial layers, which in males shows itself in the closure of the sinus pocularis. The cyst may be often discovered projecting from the urethral orifice."

The short and simple tract of the female urethra, and the yielding character of the tissues surrounding it, enable the surgeon to examine the interior of the bladder through this passage more readily than is possible with the male. Foreign bodies and calculi are removed with relative ease. Stricture of the female urethra for evident reasons is an insignificant affection as compared with that of the male urethra, and is never induced by gonorrhœa, but invariably by the results of violence, more particularly following injuries of the parts in labor.[3]—The urethra is elongated during parturition to twice or three times its ordinary length. It is at such times necessary to use a long elastic catheter to reach the bladder.[4]

THE FEMALE PERINEUM.

The Female Perineum includes the structures occupying the inferior pelvic outlet. It constitutes the true pelvic floor, and is a thick fleshy diaphragm which presents inferiorly a convex, and superiorly a concave surface. The plane of the floor is interrupted by the vesical, vaginal, and rectal outlets, lines extending from which serve to limit the subdivisions of the perineum.

The female perineum is divided into a pubic and a sacral segment.

The *pubic segment* consists of that portion which extends from the symphysis pubis to the anterior

[1] The account of the urethra naturally follows that of the bladder. The description of the female urethra, since its relations are chiefly with the vulva, is here introduced under the general heading of the female organs of generation.

[1] Archiv. Gén. de Méd., Avril 28, 1867.

[2] Wien. Med. Jahrbuch., iii. 373; tr. in N. Y. Med. Journ., xx. 653.

[3] T. B. Curling, Lancet, i. 634.

[4] For an elaborate description of the urethra in the female with figures, see M. Schüller, Virchow's Archiv, 1883, cxiii. 405.

vaginal wall inclusive, and is for the most part composed of the bladder. It is loose in its attachments; is drawn up during labor; is driven down in prolapsus uteri, and falls forward in the genu-pectoral position.

The pubic segment, as seen on a median antero-posterior (sagittal) section, is triangular in shape, and exhibits a pubic, a vaginal, and a peritoneal aspect. The *pubic aspect* is nearly two inches and a half (six cm.) long, and is separated from the symphysis pubis by a pyramidal mass of fat. The *vaginal aspect* is three and a third inches (eight cm.) long, and is closely incorporated with the anterior vaginal wall. The *peritoneal* aspect is of the same length as the pubic.

The *sacral segment* extends from the posterior vaginal wall to the sacrum. It is somewhat quadrangular, and is composed of musculo-tendinous tissue. The lower end of the structures entering into the anterior wall constitutes the so-called "perineal body." The sacral segment is firm in its attachments; is drawn down in labor; always remains in position (posterior vaginal wall excepted) in prolapsus uteri, as well as in the genu-pectoral position.

The superficies of the parts entering into the female perineum embrace, (1) the space between the tip of the coccyx and the anus; (2) the anus itself; (3) the space between the anus and the commissure; (4) the vulva. In practice, however, it is customary to restrict the term perineum to the third of the above-named divisions.

The female perineum (perineal body), (Fig. 192, Fig. 193), when thus restricted, is the superficies of the anterior portion of the sacral segment of the pelvic floor. When seen as part of an antero-posterior (sagittal) section (Figs. 194 and 195), it is a broad musculo-tendinous surface, which forms a conspicuous feature in the dissection; it is covered with skin on its free and inferior aspect; but is continuous with the mucous surface of the vagina anteriorly, and the mucous surface of the rectum posteriorly. Its superior limit is not well defined in the dead subject, but in the living can be said to correspond to the plane of the upper limit of the Internal Sphincter Ani muscle.[1]

According to Jas. St. Clair Gray,[2] there is great diversity in the position, length, and relation of the perineum to the pubis and the coccyx. When the perineum is long and its anterior margin is near the pubis, it may be termed *pubical;* when shorter and equidistant from the pubis and coccyx, it may be termed *axial;* and when nearer the coccyx, *coccygeal.*

In connection with this subject, it may be here appended that the orifice of the vagina is not constant in its position relatively to the pubis and coccyx, nor is the direction of its cavity invariable. The sacrum is inconstant in form. It varies in the degree of curvature of its anterior surface, and when the curvature is slight the perineum has an axis which answers to the *coccygeal;* when moderate, the axis is central or *axial;* and when the curvature is exaggerated, the axis is *pubical.* Thus differences in the position of the perineum correspond with degrees of curvature of the sacrum.

THE MAMMÆ.

The Mammæ (mammary glands) (fig. 4, Plate CIX.) are the milk-producing organs. They are subcutaneous bodies, situated one on each side of the front of the thorax, over the Pectoralis Major muscle. They are characteristic of the highest group of the animal kingdom, the mammalia.

The mammæ are equally active in both sexes in utero; are equally inactive during infancy and adolescence; but differ remarkably during the years of fertility. The description, here adopted, relates, unless otherwise stated, to the glands in the child-bearing woman.

The mammæ are generally described with the organs of reproduction, in consequence of their development proceeding coincidently with these organs. In the female before puberty, and in the male throughout life, the mammæ remain in a rudimentary condition.

Each mammary gland forms a hemispherical or sub-conical eminence—the breast—surmounted by the nipple, and diverges slightly from its fellow. It is somewhat flattened above, convex below, slopes gently toward the axilla, extends from the third to the seventh rib, and from the outer border of the sternum to the anterior border of the axilla.

The nipple is of a deep brown color in the brunette; the areola assumes a peculiar brownish hue in pregnancy. It lies as a rule opposite the fourth intercostal space. It is often over the fourth rib, less frequently on the fifth rib, and rarely upon the fifth intercostal space, and lies four and three-quarters of an inch (twelve cm.) from the median line of the sternum. According to Holden, a line

[1] The above account is based for the most part upon the researches of D. B. Hart, The Structural Anatomy of the Female Pelvic Floor, Edinburgh, 1880.—See also Edinburgh Medical Journ. xx.; also, B. E. Holden, Am. Journ. Obst., etc., xvii. 1884, 365.

[2] Glas. Med. Journ., 1874, 182.

drawn round the chest through the nipple crosses the sixth intercostal space midway between the sternum and the spine.

Scattered over the areola are from five to ten minute wart-like growths, the papillæ; these represent the terminal points of minute glands, which, from their resemblance to the mammæ, are called the *accessory lacteal glands*. They present an average diameter of one line. They are not to be confounded with the *sebaceous* glands which exist here as upon other portions of the general skin surface, and open *between* the papillæ; but they have especial significance here, since they lubricate the nipples during the act of sucking, and thus prevent excoriation of the delicate skin of the nipple which would in their absence occur.

Measurements.—The mammary gland measures from three-and-a-half to four-and-a-half inches in diameter, and from one-and-a-half to five inches in thickness.

Upon its removal the gland is observed to have a slightly concave base, which rests upon the Great Pectoral muscle, and in a well-developed condition even encroaches upon the Serratus Magnus muscle. It is surrounded by abundant connective tissue and fat. The former is of importance in retaining the gland in position, and is especially well developed at the upper portion, where it has received from A. Cooper the name of the *suspensory ligament* of the breast.

Beneath the mamma lies a bursa (sub-mammary bursa) which enables the gland to be freely moved upon the wall of the chest. To demonstrate the bursa an incision can be made which bisects the gland. The outer (lateral) half of the gland can then be turned outward toward the axilla, and the bursa is exposed.

The sub-mammary connective tissue following the strain of successive periods of lactation becomes relaxed, when the mammæ hang, udder-like, upon the thorax. This condition is especially well developed in women in savagery—the gland at no time receiving artificial support. In some African tribes it has been asserted that the breast may be slung over the shoulder in suckling the child, which is strapped to the back.

Structure.—A section of the mamma exhibits a whitish-yellow parenchyma, streaked here and there with a pinkish color. It is composed of from twelve to fifteen lobules which converge and terminate by as many orifices at the nipple.[1] The lobules widen toward the periphery, and are composed of vesicular terminations (*acini*), closely resembling the plan of structure of the racemose glands of the mucous membrane. These have received the name of the *lactiferous ducts* (*galactophorous ducts*). As they are about to terminate in the nipple, each forms a fusiform expansion (ampulla), and within the nipple becomes much contracted. The diameter of a duct is one-twenty-fourth of a line, that of an ampulla from two to four-and-a-half lines, and that of the termination of a duct in the nipple one-twelfth of a line.

The ducts contain abundant elastic tissue in the walls, but no muscular fibre. The cells in the vesicles are rounded or sub-angulated; the epithelial cells of the ducts are short, and columnar.

The nipple contains unstriated muscular fibres, which are arranged in intersecting circular bundles. A few straight fasciculi pass from without inward.

Since in lactation the milk is being constantly secreted, it tends to flow forward from the vesicles. But, unlike the racemose glands elsewhere, the orifices of the ducts, in addition to being much narrowed, are actually closed by muscular contraction. The milk is thus retained in the ducts, more especially in the region of the ampullæ, until the infant, being placed at the breast, elongates and relaxes the constricting fibres (aided by the vacuum created by the act of sucking), and causes the milk to flow.

Bloodvessels.—The *arteries* supplying the gland are branches of the long thoracic, the acromial thoracic, the internal mammary, and the intercostal arteries. The *veins* belong to the superficial cutaneous veins.

Lymphatics.—The lymphatics are large and numerous. They terminate for the most part in the axilla, although some join the glands in the mediastinum.

Nerves.—The nerves for the skin are derived from the supra-clavicular, and the external branches of the intercostals from the second to the sixth, as well as branches derived from the brachial plexus. The parenchyma is supplied by the fourth to the sixth intercostal nerves. According to Luschka, Pacinian corpuscles are found upon the terminal twigs of the nerves about the nipple.

Variation.—The mammæ are subject to variation in numbers and position. Examples of such are, however, rare. Three supernumerary glands have been found associated with the normally situated mammæ. Instances of single supernumerary glands have been recorded, situated in the regions of the back, of the axilla, and of the thigh. In the latter instance the gland afforded an abundant secretion.[1] The mammæ are not always symmetrical. The gland rarely possesses two nipples. The left gland, according to W. B. Woodman, more commonly exhibits this peculiarity, it being commonly the larger.[2] At birth the mammæ resemble

[1] Luschka gives from twelve to fifteen lobules; Quain fifteen to twenty.

[1] Luschka's "Die Brust," 250, where reference is given to Roberts in Meckel's Path. Anat. der Brustdrüse. Illustr. Mediz. Zeitung., Munich, 1852, 142. See, also, A. H. Cameron, Journ. of Anat. and Phys., 1879; Ibid., J. M. Bruce, 425.

[2] Trans. Obstet. Soc. Lond., 1868, 51.

sebaceous glands, having a single duct. During childhood the ducts multiply, by which an increased growth of the entire gland is implied.

Remarks.—The mammary gland is remarkable for the periodicity of its functional activity. In the fœtus it assists in secreting the sebaceous matter (vernix caseosa) which protects the skin of the embryo from dangers of maceration. This phase of activity, as a rule, persists for a short time after birth, and may determine congestion and even suppurative inflammation about the nipple. During infancy (with the exception of the few days indicated) and childhood the glands are inactive, but in the female, toward puberty, they enlarge, and in the period extending between the fifteenth and the forty-fifth year are capable of assuming great increase in size and in function. After the forty-fifth year, at a time corresponding to the cessation of the menstrual period, the glands cease to secrete, and undergo atrophy of the cellular elements. At this period they are liable to incursions of morbid action, notably from carcinoma.

The lymphatics of the axilla are usually involved in advanced states of malignant growths. Galactocele arises from the accumulation and retention of milk in the lactiferous ducts.

THE SKIN.

The Skin (integument, cutis[1]) is a sheet-like elastic covering to the superficies of the body. It is designed to protect the delicate underlying structures, to permit of the exudation and absorption of liquids, to conserve animal heat, and to accommodate the organs of touch, the sebaceous glands, and the sweat-glands. The hair and nails are appendages to the skin which supports them.

The skin is composed of two great divisions, the dermic and the epidermic.

The *dermic* layer is subdivided into the papillary and the reticular layers; and the *epidermic* layer into the spinous, granular, lucid, and cuticular layers.

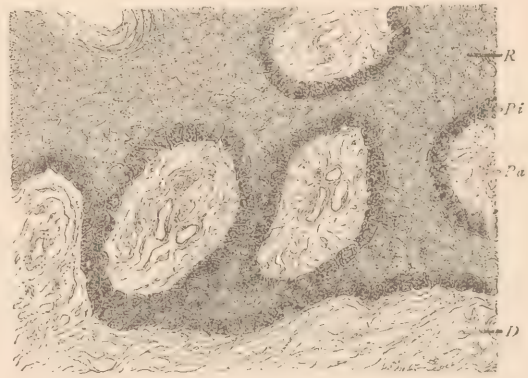
The Derm (true skin, cutis vera, corium) is composed for the most part of interlacing fibrous bands, which gives the skin in great part its thickness, and to which its protective value is due. It accommodates the papillæ, the sweat-glands, the sebaceous glands, the hair-follicles, and receives the bloodvessels, nerves, and lymphatics. The true skin is composed of two principal portions, which, however, merge into each other: a *papillary layer* (superficial layer), which receives the papillæ, and is made up of a compact arrangement of fibrous tissue; and a *reticular layer* (deep layer), which is composed of coarser fibres; these fibres form reticulations for the retention of firm aggregation of fat-cells (panniculus adiposus). The reticular layer gradually passes into the fat of the subcutaneous connective tissue.

The papillæ are widely distributed, though they may be absent in some areas. They are best developed on the palms, the palmar aspects of the digits, the clitoris, the penis, the nymphæ, and the nipples, where they are elongated; upon the face they are shorter. They are well-developed in the negro (see Fig. 196).

The papillæ of the skin are small, short, conical, or sub-conical elevations of connective-tissue fibrillæ which accommodate the tactile corpuscles or loops of bloodvessels and lymphatic vessels. The papillæ vary in form; when several are united to a common base, the term *compound papillæ* designates them.

The papillary bodies are arranged in folds and ridges which are of great delicacy and intricacy. They are best developed upon the palmar surfaces of the fingers and the plantar surfaces of the toes. According to H. P. Bowditch, they are of constant value in the individual, and aid in the study of the identification of the body.

Fig. 196.



Horizontal section through the scalp of a negro. *R*, Spinous layer; *Pi*, row of columnar epithelium surrounding the papillæ; *Pa*, papilla cut transversely; *D*, papillary layer of the true skin.

The Epidermic Division is divided into four layers, as already mentioned, the spinous, the granular, the lucid, and the cuticular layer.—The *spinous layer* (prickle layer, mucous layer, rete Malpighii, stratum spinosum) is the deepest of the layers, and lies directly upon the papillæ. Near the true skin the cells of this layer are cylindrical in form. The cells throughout are remarkable for retaining numbers of

[1] See also, p. 37.

protoplasmic processes which, from the fact that they resembling prickles or spinous projections, has given them the name they bear. The cells of the spinous layer become flatter as they reach the surface.—Superimposed upon the spinous cells is the *granular layer* (stratum granulosum); above this the delicate *lucid layer* (stratum lucidum); and finally the flattened imbricated cells constituting the *cuticular layer* (see in extension, p. 37).—The cells of the granular layer and some of the spinous layer yield a peculiar substance which is called the *hyaline substance* of Recklinghausen (kerato-hyaline of Waldeyer). It probably serves a purpose in converting the cells of the epiderm into horn-substance, and thus aids in giving consistence to the hairs and the nails.

The muscles of the skin.—The skin is moved by muscular fasciculi inserted into it as in the instance of the Platysma Myoides, Palmaris Brevis, and the muscles of expression. The fibres of the skin can be moved upon themselves by intrinsic muscle-fibres. Such fibres are best developed in the scrotum where they constitute the *dartos*, but are also seen well developed in the nipple. No portion of the skin is entirely free from muscle-fibres, and they may be said to form two distinct groups: first, the group associated with the hair follicle (*Arrectores Pilorum*), which by their contraction can erect the hair and project slightly the walls of the follicles; and a second group called by Unna[1] the oblique tensors of the skin. The second group most probably acts in conjunction with the elastic fibres, and aids in maintaining the circulation of the blood and the lymph, as well as in facilitating the escape of sebaceous matter and sweat.

General Considerations of the Skin.—In some localities, as in the scalp, the palms and the soles, the beds of the nails, the line of Poupart's ligament, the crests of the innominate bones, the auricles, the tip of the nose, and the eminences over the spinous processes of the vertebræ, the skin is held in various degrees of fixation.

Some of these depressions of the skin are determined by muscular action, and are noticed more especially in the face, the hands, and the feet. A number of depressions almost peculiar to the face result from the traction of muscles, and are seen as "furrows" and "wrinkles" as effects of inanition and of advancing years. Dimples are pit-like depressions at points where the skin is held down to subjacent parts by delicate trabeculæ: the chin, the cheek, and the elbow exhibit them. They are most conspicuous in well-nourished persons in whom the adjacent integument is well cushioned in fat. The skin is everywhere thin in children, and possesses a relatively abundant subdermal connective tissue. As a result of this peculiarity furuncular abscess with these subjects involves the deeper parts to a greater extent relatively than in the adult. The cutis in the adult possesses an average thickness of from one-and-a half to two mm. The skin is thinnest in the eyelids, the external auditory meatus, the lips, the glans penis, and the inner surfaces of the labia majora. It is relatively thin on the sheath of the penis, the scrotum, the nipple, and exceptionally thick on the palms and the soles, the buttock and along the back. The habitual use of clothing to some extent influences the general thickness of the skin.

The margins of orifices at which mucous membrane and skin join, and which are free from cartilage, as at the oral and the anal apertures, are thin and mobile, and are liable to special invasions of diseased action. Among these may be mentioned fissure, mucous patch, condyloma, and epithelioma. In congenital ichthyosis the orifices named are of defective development (see Variations).

The skin is extensile, and when divided retracts. Not merely are these properties due to the elasticity of the fibres of the derm, but are in a measure the result of action of muscular fibres in the skin. A given surface of skin may, under a gradual force exerted from beneath, adapt itself to a large area. Thus a tumor may acquire tegumental covering without the necessity of encroaching upon the skin of regions adjacent to that in which the growth originates. In the event of removal of the tumor the skin will not retract to its former dimensions, and is usually in part excised with the growth itself. As a sequence of pregnancy it may be mentioned in connection with this subject that the mobility of the anterior abdominal wall is increased, and its indisposition to retract to the proportions customary in women prior to the first pregnancy is impaired, hence the walls are more or less pendulous and exhibit peculiar lines which result from the strain and disrupture attending the pressure of the gravid uterus. In health the skin is adapted to the outline of the limbs; but in the emaciated and in the aged, folds of skin are conspicuous in many parts of the body from the inability of the skin to conform itself to the shrunken condition of the underlying tissues.

The adipose tissue which is so abundantly deposited

[1] *Infra*, 14.

beneath the skin in health, is closely incorporated with the skin in the buttock, the palms, the soles, the lobes of the ear, and to the skin of the face, where it forms cushion-like masses to aid for the most part in the protection of the deeper parts against external pressure. The skin can be raised in folds from the subdermal structures in the neck, and in the greater part of the limbs, especially at the lines of flexion of the joints.[1]

The presence of fat, when it is moderately firm, causes the skin to form transverse folds in some portions of the body, especially in well nourished infants and obese persons. The most prominent of these folds are seen in the neck, along the limbs; one lies across the abdomen on a line joining the anterior superior spinous processes of the innominate bones.

The presence of fat in the adult, taken together with the absence or presence of hirsute growth, is a valuable subordinate sexual character, and may be employed in the determination of the question of sex in the living subject.

Variations.—The skin is singularly inapt to be the seat of congenital defect, and with the exception of the absence of the skin over the abdomen in whole or in part, the absence over the region of the heart, and the absence over the region of the vertex, occiput, or region of the dorsal spine it may be said never to suffer from congenital deformities.—When the skin about the umbilicus is defective it causes the formation of umbilical hernia.

Dermatologists include among anomalies of the skin a number of affections of the epidermic portion. Congenital ichthyosis may be accepted as a type of such a condition, and in the judgment of E. Lesser[2] is a defect not only in the epidermic division, but of the skin of the body as a whole. The skin would appear to be arrested in growth, and the distending forces of development rupture it, thus forming large transverse fissures upon the trunk, longitudinal fissures on the limbs, and failures of development of the parts dependent upon a normal union of mucous and tegumental structures, as at the palpebral fissures, the mouth, and the anus. Such subjects perish within nine days after birth.

THE NAILS.

The Nails are flexible, translucent, horny structures which arise from the epidermic layer of the skin upon the dorsal aspects of the terminal phalanges. Each nail is gently convex from side to side, and is thicker in the middle than at the edges. The nail presents a distal, free border, and fixed lateral and proximal borders. The border last named is called the *root;* the exposed portion, the *body;* the oval white space in advance of the root, the *lunula;* and the superficial structures, which aid in imbedding the nail, the *nail-folds.*—The surface upon which the nail lies and to which it adheres is called the *bed of the nail* (matrix). It is composed of a thin layer of spinous cells resting upon the true skin layer which is at this place rich in ridges bearing papillæ.

The nail is marked along its exposed portions by a number of faint, longitudinally disposed lines. When the nail is torn from its bed or allowed to fall away by maceration, the under surface is seen to be marked by numbers of more conspicuous lines. These consist of minute parallel striæ which are ranged in a single series over the entire surface, and which correspond in position to the ridges of papillæ of the nail-bed.

The *nail-folds* (perionyx, eponychium) are best seen in section.

When section of the digit is made from above downward, the root of the nail is seen to lie between the bed and a triangular portion of epiderm, which is composed, first, of a thin layer of cuticle lying against the nail; second, a layer of granular cells, and third, a layer of spinous cells.

The nail-folds have been named the *eponychium* by P. Unna,[1] who, under this name, describes a layer of epiderm belonging to the true skin and which envelops the nails in fœtal life. It is homologous with the "epitrichium" of the sloth-type of mammal. The eponychium is represented in the life-history of the phalanx by the thin translucent fold of epiderm, which exhibits a disposition to leave the derm, and, adhering closely to the nail, to advance along it from the root upon the dorsal surface. The eponychium is frequently lacerated, and when drawn forcibly backward irritates the skin and exposes the subepithelial structures. Such tags of tissue are popularly known as "hang-nails," and are the localities at which syphilitic virus and other forms of animal poisons frequently have entered the system.

Remarks.—The nails are delicate clinical tests of nutritive changes. Dr. S. Weir Mitchell has ascertained that they cease to grow in paralysis. In relapses of typhoid fever the nails also cease to

[1] The lines of flexion of the joints, the median aspect of the limb, and the inferior aspect of the trunk are the parts most protected in the embryo. They are also the parts that answer to the most protected surfaces in quadrupeds. It is interesting to note the indisposition of ichthyosis to involve these regions, and the activity of gland secretion within them.

[2] Ziemssen's Handb. d. special. Path. u. Therap., xiv. i. 1883, 479.

[1] Ziemssen's Handbuch d. special. Path. u. Therap., xiv., i., 39.

grow, but they renew their activity as convalescence progresses. G. Rolleston[1] has recorded a curious condition of the nails in cyanosis. Dr. J. M. Da Costa has demonstrated the utility of examination of the nails in doubtful cases of typhoid disease, with a view of determining the lines of growth-cessation of the nail. The transverse line of death is opaque white, the line of growth a translucent pink-color.[2]

The form of the nail varies according to general conditions of nutrition. It is highly arched or clubbed in slow wasting disease, an appearance which was at one time thought to be characteristic of phthisis.

In some forms of cyanosis the ends of the fingers have a tendency to whitlow.[3]

In subclavian aneurism the finger ends of the corresponding hand have been observed by A. Poland to be somewhat clubbed in shape, and cold and moist to the touch. The nails may be desquamating and of a dark-purplish color.[4] In a case of subclavian aneurism recorded by Langenbeck,[5] a peculiar condition of the finger ends was reported as occurring at the time when a recurrent increase of the aneurism took place, after having been quiescent for a period of three years and apparently disposed to subside spontaneously.— Suchard[1] has made a series of careful studies of the nails in diseased conditions.

Errors of nail-growth correlate with similar errors in the development of the teeth, and it is probable that the milky spots in enamel are the effects of temporary arrest of development in the enamel-organs during the process of the evolution of these structures. The nails of the first, second, and third fingers are more apt to exhibit the defects than are the nails of the fourth and fifth fingers, and all the fingers of the hands are more frequently affected than are any of the toes.

Excessive growth of hair is often associated with supernumerary growth of the teeth and hypertrophy of the mucous membrane of the oral cavity.

For an account of the Hair Follicles, the Hair, and the Glands of the Skin, see p. 43.

SUPERFICIAL AND TOPOGRAPHICAL ANATOMY.

SUPERFICIAL ANATOMY OF THE HEAD AND FACE.

The form of the skull can be easily determined by examination of the overlying soft parts. The position of the occipital, parietal, and frontal bones can be outlined as these structures enter into the vertex, and while in the infant the edges of the anterior and posterior fontanelles can be felt, the depressions answering to their former positions can be ascertained through the period of adolescence in those subjects in whom growth has been slow.

The more common bony prominences which can be detected in the undissected subject are the following: the occipital protuberance, the superior semicircular line (inconstant), the temporal crest, the mastoid process, the external angular process of the frontal bone, the malar bone, the margins of the orbit, the superciliary ridges, the boundaries of the anterior nasal aperture, the zygomatic arch, and the nasal eminence. Within the mouth the incisorial and the canine fossæ, the hard palate, the beginning of the mylo-hyoid ridges, and the pterygoid processes of the sphenoid bone can be determined. With the finger placed above the soft palate (see p. 150), the region of the true base of the skull can be felt, as well as the vomer as it aids in defining the posterior nares. The finger thrust up the nasal chamber from in front can ordinarily define the anterior end of the inferior turbinated bone and the under surface of the middle turbinated bone. The septum of course can also be distinguished.

Among the more important relations by which can be made out external signs are the following: the great longitudinal sinus lies beneath the position of the sagittal and frontal sutures from the nasal eminence of the frontal bone and the production of this line backward as far as the occipital protuberance. The position of the lateral sinuses corresponds to horizontal lines drawn from the position of the protuberance last named to the bases of the mastoid processes. The junction of a vertical line extended upward from a point behind the zygoma with a horizontal line extended backward from the external angular process of the frontal bone indicates the position of the great

[1] Nat. Hist. Rev., 1861, 488.

[2] Trans. Coll. of Physicians of Phila., iii., 1876.

[3] C. E. Hasse, An Anat. Descrip. of Diseases of the Organs of Circulation and Resp. (Syd. Soc. Trans.), 178.

[4] Med.-Chir. Trans., lii. 296.

[5] Berliner klin. Wochenschrift, March, 1859, No. 12.

[1] Arch. Anat. et Physiol. norm. et pathol., n. s., x., 1862, 445.

meningeal artery where it is liable to bleed from fracture of the skull.

The fissure of Rolando, at and near the vertex, lies an inch and three-quarters to three inches behind the bregma (see p. 145). The distance is a little greater in males than in females. The lower limit of the fissure can be determined, according to Championière, by extending a horizontal line backward from the base of the external angular process of the frontal bone, which is intersected by a vertical line two-and-three-quarter inches (seven cm.) in length. At the end of this line a vertical line is drawn, upon which, at a distance of one-and-a-quarter inch (three cm.), the lower limit of the fissure is reached.—The external part of the parieto-occipital fissure lies directly beneath the lambdoidal suture. The horizontal limb of the fissure of Sylvius extends parallel to the squamoso-parietal suture, about two inches above the zygomatic arch.

The anterior extremity corresponds to the pterion (see page 145). The frontal lobe lies in front of the bregma. The parietal lobe lies between the line of the fissure of Rolando and the lambdoidal suture. The occipital lobe lies between the lambdoidal suture and the external occipital protuberance. The sphenotemporal lobe lies below a line produced posteriorly from the base of the external angular process of the frontal bone. The position of the region of Broca is indicated by a horizontal line extended backward from the base of the external angular process of the frontal bone two inches (five cm.) in length. The posterior part of the third frontal convolution is situated nine lines (two cm.) above the posterior end of this line.

The lines mentioned being determined on the side of the head, the position of any desired portion of the cortex can be ascertained with an exactness sufficient for clinical purposes.[1]

The *skin* of the face is, with the exception of that over the Buccinator muscle, the eyelids, and the bridge of the nose, adherent to the parts beneath. Hence the creasing and the wrinkling of the skin accompanying the contraction of the facial muscles. The eyelids are remarkable in being free from fat.—The skin can be pushed up or down some distance from the line of the lower jaw. It recovers readily from injury, and disfiguring scars are of infrequent occurrence. In the event, however, of the entire depth of the soft parts becoming involved in an ulcerative process (such as is seen in some forms of mercurial stomatitis, in cancrum oris, in burns of the third degree), facial scars are exceptionally dense and immobile; the pliable skin from adjacent places, as the skin of the neck, and even from the anterior chest-wall, may be dragged up toward the cicatrized locality.[1]

The following bursæ, according to C. B. Nancrede,[2] can be located in the region of the head and face: over external occipital protuberance; temporo-maxillary articulation; at lower border of the chin; behind the Zygomaticus Major; an extension of the bursa last named passes beneath the anterior border of the Masseter muscle and comes into relation with a second bursa placed close to the coronoid process. Under certain circumstances these bursæ may extend to the base of the cranium. In the judgment of Nancrede,[3] certain rare cysts of the cheek, which may extend to the base of the cranium, probably arise from an enlargement of these bursæ.

THE SUPERFICIAL ANATOMY OF THE NECK.

The Neck is divided by two lines drawn from the anterior borders of the mastoid processes downward to the shoulders into two sub-regions. That region in front of the lines is the anterior cervical region, and that back of them the posterior cervical region.

The Anterior Cervical Region is divided into three regions: a median, and two lateral. The plan of these regions and their subdivisions is as follows:—

Median Cervical Region.	Supra-Hyoid Region. Sub-Maxillary Region. Infra-Hyoid Region. Sterno-Mastoid Sulcus. Carotid Triangle.
Lateral Cervical Region.	Retro-Maxillary Region. Sterno-Mastoid Region. Supra-Clavicular Region.

The Median Cervical Region has been compared to the figure of a kite, *i. e.*, to one composed of two truncated triangles, placed end to end, at their bases. The line of the hyoid bone represents the union of the bases of the triangles, the upper triangle forming the *supra-hyoid region*, and is defined above by the lower border of the inferior maxilla, and at the sides by the lines of the anterior bellies of the Digastric muscles. The

[1] The foregoing section is epitomized from Tillaux. (Traité d'Anat. Topogr., 63.) A more elaborate account is framed by E. Gavoy (Atlas d'Anat. Topogr. du Cerveau, etc., Paris, 1882, 149). See also a succinct statement based on research by W. Turner (An Introduction to Human Anatomy, Edinburgh, 1877, 266).

[1] See also Remarks on pp. 250, 252.

[2] International Encyclopædia of Surgery, ii. 1882, 705.

[3] Loc. cit.

lower triangle, known as the *infra-hyoid region*, is defined below at the sides, by the median borders of the Sterno-Cleido Mastoideus muscles, as they approach the sternum.

The Supra-Hyoid Region (hyo-mental) is best seen when the head is thrown back, but best examined by palpation when the head is brought forward. It defines the space between the lower jaw and the hyoid bone.

The Sub-Maxillary Region. When the head is slightly inclined forward, this region lies on a nearly horizontal plane, and its lower limit is readily defined, for in this position the body of the hyoid bone can be readily felt beneath the skin. The central part of the region answers nearly to the position of the Genio-Hyoid muscles. These muscles can be felt to contract beneath the finger in the first act of deglutition and in the pronunciation of the letter *V*. The position of the sub-maxillary salivary glands, and not infrequently the superficial sub-maxillary lymphatic glands, and the anterior bellies of the Digastric muscles, can be determined.—The *skin* of the sub-maxillary region is loose to permit the free motion of the head and of the lower jaw. It is more fixed at the border of the under surface of the chin than elsewhere. At the sides two conspicuous folds of skin are seen in the aged. The skin can be drawn up toward the face, and in the cicatrices resulting from burns the tractile force may be sufficient to depress the lower jaw. The sub-maxillary region is of surgical interest, since it is here that the floor of the mouth is opened in amputation of the tongue, and that pus gravitates from deep-seated abscess of the lower jaw.

The Infra-Hyoid Region (jugular region, nearly) in a strict sense represents the front of the neck when the face is directed forward. Beneath the skin can be felt the prominence of the thyroid cartilage. In females and in children the prominence of the thyroid cartilage is absent, and in the former may be lost in the even convex surface of the neck.

In addition to the foregoing are noticed the cricoid cartilage, the thyroid body, with its incisure, and the beginning of the trachea. The upper border of the thyroid cartilage can be determined, as well as the space between this cartilage and the hyoid bone. The lower part of the infra-hyoid region (sulcus sterno-mastoideus) is defined by the median borders of the Sterno-Cleido-Mastoideus muscles at the sides, and the supra-sternal notch below. The parts lying within these boundaries are not, as a rule, detected from without. They represent the trachea, fascia, and fat. In children the innominate artery can be felt pulsating in this space.—The *skin* of the infra-hyoid region is very movable to enable the laryngeal and tracheal apparatus free play of motion. Care should be taken to fix the skin in making incisions in this region. This is more particularly of importance in the performance of tracheotomy. The branches of the external jugular and anterior jugular veins are conspicuous in this, and in the lateral cervical regions. Conspicuous among the superficial structures of the neck which may have clinical interest, is the bursa surrounding the tendon of the Digastric muscle. Bursæ are also lodged between the skin and the neighborhood of the thyroid cartilage; these have received the names of ante-thyroid, infra-hyoid, and supra-hyoid bursæ.

The Sterno-Mastoid Sulcus (carotid region, nearly).—A shallow groove lies between the Sterno-Cleido-Mastoideus muscle, the larynx, and the trachea. It is continuous above with the retro-maxillary fossa, and below is lost in the jugular region. That part of the recess which lies between the median and lateral structures of the neck is of special interest, since it transects the line of the greater cornu of the hyoid bone, and has received the name of the *carotid triangle;* and that part which lies between the trachea and the median border of the Sterno-Cleido-Mastoideus has received the name of *sterno-mastoid sulcus proper*.

The Carotid Triangle (trigonum carotideum) is broader and deeper than the remaining portion of the groove, and corresponds to the position of the common carotid artery, as this vessel is about to divide into the internal and external carotid arteries. The term carotid triangle is derived from the circumstance that in dissection the median border of the Sterno-Cleido-Mastoideus, the line of the posterior belly of the Digastric, and the line of the anterior belly of the Omo-Hyoid muscles define it. The triangle, in a study of surface-anatomy, is chiefly interesting for the marked pulsation which is distinguishable here. In many conditions of health, particularly in the anemic condition of females, which verge toward or are identified with exophthalmic goitre, the pulsations are very decided. It is here that the arteries are known occasionally to enlarge in calibre (see p. 366), and it would be an interesting point to determine, in subjects in which such enlargements occur, the ante-mortem conditions with which the swellings were coincident.

The infiltrations attending acute laryngitis and pharyngitis may so change the relations of the vessel in the carotid triangle as to lead the incautious in examining the superficies to mistake the vessel for an engorged lymphatic gland.

The Lateral Cervical Region embraces the neck between the Sterno-Mastoid sulcus and a line produced from the mastoid process. It is chiefly remarkable for the conspicuous prominence at its upper two-thirds, which is caused by the belly of the Sterno-Cleido-Mastoideus muscle, and for the depression behind the lower jaw and above the clavicle.

The Retro-Maxillary Region is the space beneath and behind the prominence formed by the angle of the jaw. The depression above and behind the lobule of the ear is called the *sub-auricular fossa.* The region is defined posteriorly by the mastoid process. The transverse process of the atlas can sometimes be felt at the base.—The *skin* of the retro-maxillary region is everywhere lax, and permits the finger to define the inner contour of the angle of the jaw. The lower lobule of the parotid gland can be felt in some subjects.

The upper portion of the region has received the name of the Sterno-Mastoid region, and embraces the origin and belly of this muscle the greater part of its length.—The pus from a mastoid abscess has been known to flow into the digastric groove of the temporal bone, and following the occipital artery and the posterior belly of the Digastric muscle, to diffuse itself through the deep tissues of the neck beneath the Sterno-Cleido-Mastoideus muscle.[1]

The Supra-Clavicular Region embraces the region immediately above the clavicles between the opposed borders of the Trapezius and Sterno-Cleido-Mastoideus muscles. The recess near the outer portion of the bone is of interest from the fact that it is in this fossa that the third portion of the subclavian artery can in some individuals be found pulsating, and within this fossa the first incision is made in the operation for ligation of the subclavian artery at its outer third.—Numbers of lymphatic glands are present in the supra-clavicular region.—The process of the cervical rib can sometimes be detected here.[2]

The apex of the lung enters into this region, and it also receives the trunk of the external jugular vein. The pulsation of the transverse cervical artery can sometimes be distinguished in the supra-clavicular fossa.

The Posterior Cervical Region.—The *skin* of this region is thick and leathery. In backward traction of the head it is thrown at its upper part into a number of parallel transverse folds. Above, where it merges into the scalp, it is rich in hair follicles, and in sebaceous and sweat-glands. The subcutaneous connective tissue is abundant, compact, and occupied by trabecular bands holding the skin to the associated bones and muscles. It is a common site for painful forms of furuncle and carbuncle, and yields occasionally the nidus of origin of pedunculated fatty tumors which may attain enormous size. If the line of the lower border of the inferior maxilla be produced backward, it will cross the posterior cervical region at a point which answers to the position of the transverse folds just mentioned, and will serve as the inferior border of the *nape of the neck*, the superior border of which space corresponds to a line crossing the occiput just below the occipital protuberance.

A conspicuous fossa (fovea nuchæ) is ordinarily defined in the nape of the neck between the muscular elevations corresponding on each side to the upper portion of the Complexus and Biventer Cervicis muscles, and the thin overlying Trapezial sheet. The fossa is best defined in children from the fifth to the twelfth year; it is least conspicuous in obese male adults, and may be entirely absent in women. The bottom of the fossa answers to the space between the occipital bone and the arch of the axis, and includes the posterior arch of the atlas. From its relation to veins as they pass out from the brain-case, and to the pharyngeal plexus it is the favorite locality for the application of cups.

The posterior surface of the neck below the nape answers to the upper part of the lozenge-shaped membranous intersection of the Trapezii muscles.—The spines of the cervical vertebræ are not felt beneath the skin until the seventh cervical is reached.

A bursa which may become sufficiently large to attract the attention of the surgeon is lodged over the spinous process of the seventh cervical vertebra.

[1] Fr. Berzold, Deutsche Med. Wochenschr., No. 28, 1881; see also Am. Jour. Otol., iv. 1882, 146.

[2] T. J. Shepherd, Am. Journ. Med. Sci., clxix., N. S. 1883, 112 (fig. and literature).

THE SUPERFICIAL ANATOMY OF THE CHEST.

The Chest is that part of the trunk whose framework is secured from the thorax.

It presents for examination—[1]

The Anterior Thoracic Region.

The Posterior Thoracic Region.

The Anterior Thoracic Region.—The anterior aspect of the chest is continuous with the median surface of the upper extremity by the line of distribution of some of the nerves and lymphatic vessels common to both localities, *e. g.*, the intercosto-humeral nerve, and by the range of the lymphatic trunks from the arm to the sides of the chest at the axilla.

For convenience in description, any line desired for purposes of description in locating a wound, a growth, distribution of eruptions, or for other clinical purposes, can be referred to a line drawn downward from the sternal, middle, and acromial portions of the clavicle, or at any intermediate point. Thus the guides to the superficial anatomy of the chest are three in number, the clavicle, the sternum, and the ribs.

The *clavicle* constitutes the most important of these guides. It furnishes a main line—the *mammary line*—which is drawn downward from the clavicle in such direction as to traverse the front of the chest through the nipple.

The *sternum* affords a median line for the anterior thoracic region, to which bilateral parts can be referred. This line is of especial use in reporting results of post-mortem examinations, and in locating tumors in the anterior mediastinal space.

The *ribs* are very generally used in locating clinical conditions. The determination of the ribs from above downward, aided by the position of the sternal line and of the clavicular line, will give any selected locality with sufficient exactness. The *axillary line* of Conradi extends from the origin of the Scalenus Posticus to the free end of the tenth rib.

The anterior thoracic region is divided into various divisions which are purely arbitrary in character, and need not be here outlined. Among the localities which are sufficiently well defined for the most part by the titles, are the *sternal region*, which corresponds to the position of the sternum (sterno-costal region); the *infra-clavicular region*, which answers to the space bounded above by the lower margin of the clavicle, and below by a line extended horizontally outward from the upper margin of the sternum, and which at its lateral limit corresponds to the summit of the axillary space; the *mammary region*, which answers to the position of the mammary gland; and the *infra-mammary region* (diaphragmatic region, nearly), which extends from the lower margin of the Pectoralis Major in the male, and from the lower border of the mammary gland in the female, to the ninth rib.

The *skin* of the anterior thoracic region is much thinner than the posterior. It is tense and but slightly movable over the sternum, and presents, when compared with the skin of other regions, low reparative power. The lips of an incision made in this region tend markedly to separate one from the other. In caries of the sternum the skin is inflamed, and may be ulcerated to an extent almost equalling the surface involved by the disease itself. The skin over the mammary region increases in delicacy as it approaches the nipple, and becomes darker in color. It is apt to be fissured in lactating women. A number of the diseases of the nipple have their origin in the same peculiarity of the skin. Thus the nipple is liable to eczematous affections, and to a peculiar form of cancerous involvement. The skin of the mammary region is smooth in the child and in the virgin, but becomes wrinkled in the woman who has borne children.—At the sides of the chest, namely, about the parts traversed by the axillary line, the skin, owing to the lines of traction of the Pectoralis Major, Pectoralis Minor, and Latissimus Dorsi muscles and the scapula, is very mobile. The course of the superficial nerves as they pass obliquely downward and forward on the side of the chest is outlined by crops of vesicles in herpes zoster.

The structures which can be located beneath the skin are liable to some variation according to the age and the condition of health of the subject. In average states of the adult the anterior surface of the sternum can be outlined as well as the costal cartilages; the ribs can be also felt. The most conspicuous muscle is, of course, the Pectoralis Major; next in order appear the fifth, sixth, and seventh digitations of the Serratus Magnus. The landmarks of the lower portion of the chest, especially at the sides, also vary, particularly in females, in which class of subjects the lower ribs are often distorted by long-continued use of corsets.—Jacobi[1] has directed attention to a bursa over the xyphoid cartilage in rachitic children.—Of the mammary gland, and the lower border of the thorax and attached muscles, see the accounts of this gland and the thorax.

The Posterior Thoracic Region is naturally a part of

[1] Richet divides the chest into the main divisions of sternal or anterior wall; costal or lateral wall; and diaphragmatic wall.

[1] Am. Journ. Obstet., 1875, viii. 165.

the general surface of the "back," but is less sharply defined than either the posterior cervical region or the loin. It may be said to lie posterior to the axillary lines; below a line drawn transversely across the neck beneath the seventh cervical spinous eminence; and above a line drawn transversely one-half inch beneath the free ends of the tenth ribs. It will be observed that neither of the lines last named is exact, since the upper line does not strictly correspond to the position of the clavicle, while the lower omits the eleventh and twelfth ribs. But the twelfth rib at least cannot be constantly felt from behind.

The parts that can be distinguished in the back are the contour of the Erector Spinæ muscles; the groove-like depression (spinal furrow) answering to the spinous eminences lying between these muscles; the fleshy eminence due to the Latissimus Dorsi and Teres Major muscles as these muscles lie along the axillary border of the scapula; the spine and angle of the scapula; and the depression for the attachment of the lower set of Trapezial fibres to the bone last named.

The *skin* on the back of the chest is thick and brawny. It is loosely connected to the muscles and fascia, as a result of which peculiarity a ball, or other missile, lodged beneath the skin of the back, possesses a tendency to gravitate, and may be found lying just above the sacrum. Bedsores often occur on the back over the position of the scapulæ, and at the lower median portion. The pressure of burdens may cause bursæ to appear over the dorsal spine and the Supra-Spinatus muscles. For "landmarks" of the scapula and the vertebral column, see p. 172 and p. 166.

The *axilla*[1] (armpit), while belonging in part to the anterior and in part to the posterior thoracic region, is usually treated of as a separate region. It constitutes that triangular space whose summit (apex) lies at the junction of the skin over the second rib with the median surface of the arm; whose sides are formed respectively by the Pectoralis Major and the Latissimus Dorsi and Teres Major muscles; and whose base answers to an imaginary line uniting these muscles. The lower border will of course vary in different subjects. In a general way it may be said to answer to the line of the fourth rib.

The axilla is best defined when the arm is elevated. It is here that the intercostal spaces are readily outlined, since the ribs do not lie so near one another as at points lower down, *e. g.*, between the seventh and tenth ribs, where they may be almost, if not quite, contiguous. Lymphatic glands when moderately enlarged can be felt beneath the skin in the armpit. They are at this place frequently engorged in carcinoma of the mammary gland and in inflammation of the lymphatic vessels of the arm.

The *skin* of the axilla is mobile and furnished at the summit with a clump of long hairs. Both sweat-glands and sebaceous glands are well developed in this region.

[1] It is necessary to remember that the term "*axilla*" is here restricted to the superficies.

THE SUPERFICIAL ANATOMY OF THE ABDOMEN.

The trunk between the chest and the pelvis is conveniently divided into two portions which are comparable to the anterior and posterior regions of the neck and chest. The anterior region forms the "anterior abdominal wall;" and the posterior region the "loin."

The Anterior Abdominal Wall.

The Loin.

The Anterior Abdominal Wall[1] extends from the lower margin of the thorax to the iliac crest and the line of Poupart's ligament. Laterally the region ex-

[1] This surface will correspond to the antero-lateral region of Angers and Tillaux, and the two regions of Richet, the anterior and the lateral region of the abdomen. Clinical reports rarely locate conditions in any other region than those outlined on p. 736.

A natural subdivision of the anterior wall of the abdomen might be based upon the following statements:—

The integument of the anterior surface of the abdomen is continuous with that of the inguinal regions, the pudendal regions, and the median surfaces of the thighs by the distribution of some of the anterior branches of the dorsal and lumbar nerves among the last named, the ilio-hypogastric, the ilio inguinal, and the genito-crural nerves. From the position of the umbilicus upward it is controlled by the intercostal nerves, from the eighth to the ninth inclusive; while below the umbilicus it is controlled by the tenth to the twelfth inclusive, together with the anterior branches of the ilio-hypogastric and the ilio-inguinal nerves.—The umbilicus is situated on a line which answers to the middle and most constant of the inscriptions of the Rectus muscle, and about on a second line which answers to the production downward and forward of the eleventh rib. When it is remembered that the ductus venosus extends from the umbilicus upward to the liver, and that the bladder and urachus, from the pubis upward toward the umbilicus, it must follow that the best division of the abdominal wall would be into two portions, a supra-umbilical and an infra-umbilical, and that the subdivision of these regions should be along the oblique lines which correspond to the position of the floating ribs and of the nerve-tracts of the abdomen.—The proportions of the fœtal liver near term would bring this most bulky of the organs of the upper belt well down to the position of the umbilicus, and in the fœtus at term, at least, the abdomen might be divided with propriety into an upper and lower belt, the middle being discarded.—In the arrangement of the regions, the plan of Bright (Guy's Hosp. Rep., ii. 1837, 432) has been followed in the text, and the language of this writer, as far as was practicable, used.

tends to the median border of the Quadratus Lumborum and to an imaginary line drawn upward from the process which answers to the posterior border of the anterior dorsal concavity of the innominate bone.

The right and left portions are so united in the median line that it is exceptional for a morbid involvement of one side of the abdominal wall to pass over to the parts of the opposite side.—The walls are pierced obliquely at the lower boundary by the inguinal canals, and in the fœtus by the umbilical cord.

The anterior abdominal wall is divided arbitrarily into nine regions, as follows:—

Upper Belt	The Epigastric, The Right Hypochondriac, The Left Hypochondriac.
Middle Belt	The Umbilical, The Right Lumbar, The Left Lumbar.
Lower Belt	The Hypogastric, The Right Inguinal, The Left Inguinal.

The Epigastric and Hypochondriac regions form a natural division of the anterior abdominal parietes, inasmuch as they aid in inclosing that portion of the abdomen which is controlled by the form of the thorax. The skin of the chest passes without fold or crease into the belt just outlined, receives nerves from the same sources as the lower portion of the chest-walls, and protects organs which at the same time secure additional protection from the lower ribs, the sides of the Diaphragm alone intervening. All its organs tend to ascend in expiration and descend in inspiration, and in morbid conditions can in many instances be determined by palpation and pressure of the lower chest walls as well as of the walls of the abdomen. This portion of the abdomen is sometimes called *epigastric*, although later custom has restricted this term to the middle part only.

The upper boundary of the upper belt is the Diaphragm; the lower boundary is an imaginary line drawn between the anterior extremities of the tenth ribs. The cartilage of the tenth rib forms ordinarily a distinct projection. A horizontal plane carried backward from the line will pass between the bodies of the first and second lumbar vertebræ, and emerge posteriorly at the lower edge of the spinous process of the vertebra first named.

The upper boundary of the upper belt, being formed by the Diaphragm, varies in its position at each effort of respiration. Anteriorly, it corresponds with the junction of the xyphoid cartilage with the sternum; but from this point it will be found to descend from before backward toward the spine, and on either side toward the ribs, until it reaches the lower boundary of the belt.

The Epigastric Region (scorbiculis cordis, præcordium). This region is broader below than above, and contains the whole of the left lobe of the liver and a part of the right, together with part of the gall-bladder, the ducts, hepatic vessels, Glisson's capsule, the pyloric end of the stomach with the commencement of the duodenum, a portion of the transverse colon, the pancreas, the abdominal aorta, and the cœliac axis, with the inferior cava and superior mesenteric artery.

The Right Hypochondriac Region. This region contains nearly the whole of the right lobe of the liver, the hepatic flexure of the colon, and a small portion of the right kidney with the corresponding supra-renal capsule.

The Left Hypochondriac Region. This region contains the rounded cardiac portion of the stomach at all times; but a very large part of that organ when distended, the splenic flexure of the colon, the spleen, and a small portion of the left kidney with the supra-renal capsule.

The right hypochondriac, the epigastric, and the left hypochondriac regions are in a measure separated from the remainder of the abdomen by the transverse mesocolon. In many clinical studies such tendencies are found emphasized by the presence of bands of peritoneal adhesions. In this, the upper portion of the abdomen, are suspended the most numerous and bulky of the abdominal viscera. Diseased action is frequently herein localized, not only in the interior of the several organs, but in their interspaces as well, as between them and the abdominal walls or the intestines.

C. Hilton Fagge has analyzed a number of cases of abscess exhibiting such localization, and finds the cases susceptible of division into two groups: (1) those in which an abscess is situated in the right hypochondrium, lying between the liver and the Diaphragm; and (2) those in which the affected region is the left hypochondrium, pus having formed in a cavity bounded by the spleen, the stomach, and the Diaphragm. These cases have a tendency to terminate fatally by involving the pleura by direct transmission of the inflammatory process, or by rupturing the Diaphragm and creating a secondary empyema.

In one instance of an abscess, which was apparently a sequel to cancerous involvement of the gastric pylorus, the pus had accumulated in a space in advance of the liver, below the Diaphragm, and behind the anterior abdominal wall. It was prevented from gra-

vitating and involving the peritoneal cavity by adventitious adhesions, which extend from the pylorus to the anterior wall of the abdomen. In a second case the pus was due to disease in the pleural sac, directly through the Diaphragm.

Collections of pus may form about a ruptured spleen, and involve the retro-peritoneal space. Such abscesses may invade the tissues both in front and behind the œsophagus, and press the kidney and supra-renal capsule downward and inward. In another instance of abscess in the left hypochondrium and epigastric region, Fagge determined that the pus had found its way into the transverse colon. In yet another, the stomach was adherent by its cardiac end to the spleen, the latter organ being fixed in its turn to the Diaphragm and the kidney. The pus had entered the capsule of the spleen, and partially involved the kidney.—For involvement of the upper belt by wandering gall-stones, see p. 672.

The Middle Belt includes the umbilical, the right lumbar and the left lumbar regions.

The Umbilical Region.—The umbilical region is bounded above by the lower epigastric plane, and below by a horizontal plane passing through the anterior superior spinous processes of the innominate bones. This plane, if produced backward, will cut the centre of the second portion of the sacrum on the anterior surface of the bone, and emerge posteriorly between the second and third sacral spines.

The umbilicus lies on a horizontal line; this line is near the level of the highest point of the crest of the ilium, and it answers to the anterior edge of a plane the posterior edge of which bisects the vertebral column at about the third dorsal vertebra.

The umbilical region is chiefly occupied by a portion of the transverse colon, the omentum, and the small intestines; and it contains, likewise, the mesentery and its glands, the abdominal aorta, and the inferior vena cava.

T. W. King[1] describes a case of a child, fourteen months old, in whom a feculent umbilical discharge appeared, which, in the judgment of the reporter, came from a diverticulum of the intestinal tract. The opening closed after a treatment of six weeks. A second, but fatal case, is narrated in the same communication.

Intramural abscess of the abdomen, when not due to perityphlitis, is most commonly situated in the umbilical region. Such an abscess has been occasionally detected in children and adolescents. Instances are on record of collections thus originating, dissecting between the peritoneum and the muscular layer over the greater part of the anterior abdominal wall.[1]

The Right Lumbar Region.—The right lumbar region is subdivided into the lumbar region proper, and the iliac fossæ. It contains the upper part of the cæcum, the ascending colon, the lower and middle portion of the right kidney, the ureter, and a portion of the Quadratus Lumborum and of the Psoas Muscle.

The Left Lumbar Region.—The left lumbar region is subdivided, as is the right, and is occupied by the descending colon, and chiefly in the iliac fossa, by the sigmoid flexure, part of the left kidney, and the ureter.

The small intestines likewise occupy the lumbar regions on either side, and cover the ascending and descending portions of the colon.

The Lower Belt.—The lower belt includes the hypogastric, and the right inguinal and the left inguinal region.

The lower belt (hypogastric portion) is the smallest of the three. It is bounded above by the lower umbilical plane, and below by the upper margin of the pubis in the centre, and Poupart's ligament on either side; the latter forms two divergent lines extending from the spinous processes of the pubis upward and outward to the anterior superior spinous processes of the innominate bone. This region, according to Bright, may be said to be extended into the hollow of the true pelvis occupying its whole cavity.

The cavity of the abdomen may be said to terminate at a line a little above Poupart's ligament, where the peritoneum becomes reflected from the fascia transversalis in front, on to the fascia iliaca behind, thus rendering the inguinal regions of the belly smaller from above to below than its external boundaries would appear to indicate.

The Hypogastric Region.—The hypogastric region (pubic region) contains the urinary bladder with portions of the ureters, the first portion of the rectum, and sometimes a projecting convolution of the sigmoid flexure of the colon, together with some portions of the small intestines, more particularly the

[1] Guy's Hosp. Rep., 1843, 467 (figs.).

[1] See J. Manley, London Med. Gaz., n. s. xviii., 1851, 139, 185.

lower convolution of the ileum, and, in the female, the uterus and its appendages.

The transverse line extending across the abdomen between the anterior superior spinous processes of the innominate bones lies just above the supra-pubic fat, and is probably determined by the position of the bladder which lies immediately behind it. This line determines the upper limit of a region which is sometimes called *supra-pubic*. Within this region the high operation for lithotomy and the high puncture of the bladder are performed.

Below the supra-pubic space is the *prevesical space* (space of Retzius) which is defined in the triangular interval between the symphysis pubis, the bladder, and the peritoneum. It is occasionally the seat of abscess.

J. E. Pilcher[1] describes an intramural space, which lies between the Recti muscles and the transversalis fascia, as the *sub-muscular space*, and as distinct from the pre-vesical space. It is occasionally the seat of abscess following strain of the Recti muscles.

The Inguinal Regions are very limited. They comprise but a small extent of surface, and are likewise exceedingly shallow in consequence of the approximation which here takes place between the anterior and posterior abdominal walls previously to their union at Poupart's ligament.

The Right Inguinal Region.—The right inguinal region sometimes contains the lowest part, or *cul de-sac*, of the caput coli, and the vermiform process and the iliac vessels. The walls of this region are liable to involvement from perityphlitis.

The Left Inguinal Region.—The left inguinal region contains a part of the sigmoid flexure and the iliac vessels of that side.

"Assuming the foregoing as the regions into which the abdomen may be divided, it is evident that they will not correspond exactly with the extent and form of the different viscera; but that one division will often contain portions of several viscera, and one viscus will occupy portions of several divisions. Generally speaking, however, the position of the different organs will be as follows:—

"The upper belt will contain in its whole length the liver with the gall-bladder, the stomach, the contents of Glisson's capsule, the two colic flexures and part of the transverse colon, the duodenum, the spleen, the pancreas, the renal capsules, and a portion of each kidney, together with the aorta, the cava, the cœliac axis, and the commencement of the superior mesenteric artery.

"The umbilical and hypogastric are each divided into three regions, by two ascending planes passing directly backward, and drawn through the spinous processes of the pubis and the points on the tenth ribs, already alluded to as marking the lower epigastric plane. These planes diverge from each other; and if continued over the chest, will pass rather to the outside of the nipple in the male, until they reach the clavicle, not far from its acromial extremity.

"The umbilical subdivisions thus produced consist of a central region, which retains the name of umbilical, and two lateral regions. These last may be again divided into the iliac fossæ below, corresponding with the venter of the ilium."[1]

[1] Annals of Anat. and Surg., ix., 1882, 189.

THE LOINS.

The Loins (lumbar region, "small of the back") is the large square region which answers to that portion of the back which lies between the crests of the innominate bones and the lower margin of the chest. With reference to the regions of the anterior abdominal wall it answers above nearly to the middle belt. Clinical writers often restrict the term "lumbar region" to the "fossæ," one on each side of the lumbar vertebræ, and in this sense the right lumbar region and the left lumbar region can be defined.—The term *lumlo-sacral sulcus* is synonymous with the lumbar region as thus defined, and may be said to be that portion of the great spinal furrow or depression which extends along the entire region of the back on each side of the vertebral column and its associated muscles. The term triangle of Petit is often applied to a space defined laterally by the lateral border of the External Oblique muscle; medianly, by the lateral border of the Latissimus Dorsi muscle; and inferiorly by the crest of the ilium.

The lumbar region is concave in the erect position, and convex in forward flexion. The concavity is more pronounced in females than in males, and is excessive in coxalgia.

The spinous eminences of the lumbar vertebræ can be readily felt beneath the skin of the loins, and when the body is erect lie in a shallow linear depression.

The fourth lumbar spine answers to a line drawn across the loins at the level of the crest of the innominate bone.

The chief localities of the lumbar region relate to the positions of the ascending colon, the descending

[1] R. Bright, Guy's Hosp. Rep. ii., 1837, 436 (fig.).

colon, and the kidneys. Both portions of the colon correspond in position to a vertical line which extends upward from the middle of the iliac crest. The descending colon lies a little nearer the median line than the ascending, and is often found lying in front of the lateral edge of the Quadratus Lumborum.[1]

The position of the kidneys answers to the area of dull percussion in the lateral portion of the lumbar region, and which extends from the line of the twelfth rib to within nearly two inches of the crest of the ilium. The right kidney is, as a rule, from a half to three-quarters of an inch lower than the left.

Bartels[2] restricts the region of renal dulness to a space which measures two inches (five cm.) square in the "lumbar region." He states, quoting from Heller, that the lower margin of the kidney almost invariably lies within the pelvis.

According to Trousseau, the loins may be œdematous in peri-nephritic abscess.

The Upper Extremity.[3]

The Superficial Anatomy of the upper extremity is treated of under the heads of the

Region of the Shoulder.
Region of the Arm.
Region of the Elbow.
Region of the Forearm.
Region of the Wrist.
Region of the Hand.

The Shoulder. The region of the shoulder is treated by continental writers as embracing all the parts entering into the extrinsic muscles as they are inserted into the clavicle and the scapula, the region of the attachments found between the clavicle and the trunk, as well as those between the scapula and the humerus. In this book the English usage will be followed, and the front of the shoulder will be included in the anterior thoracic region; the back of the shoulder in the posterior thoracic region; and the region of the shoulder proper will be restricted to the rounded surface answering to the Deltoid muscle, and which constitutes the deltoid region of Hyrtl.

The shoulder covers the humero-scapular articulation, and answers to the upper half, nearly, of the lateral aspect of the humerus.

The region of the shoulder is very prominent in muscular individuals, but is flat or even concave in persons in whom dislocation of the head of the humerus exists, or paralysis of the Deltoid muscle has occurred.

The axilla and the lateral limit of the infra-clavicular fossa lie to the median side of the region; the swelling over the Infra-Spinatus muscle, to the lateral side; the swelling of the Triceps muscle, distally to it; and that of the Trapezius muscle, proximally.

The spine of the scapula and the acromial portion of the clavicle form parts of a continuous line which can be felt beneath the skin.

The deltoid bursa (subacromial bursa) is situated beneath the muscles at the upper margin of the region. It may be enlarged and be readily defined in the living subject. When of large size and when the

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[1] In support of the statement made on p. 274, that the muscle may be incised with advantage in searching for the gut in the operation of colotomy, L. McLane Tiffany (Maryland Med. Journ., Aug. 4, 1883) found that in four operations he was compelled to divide the Quadratus Lumborum freely; twice because the gut came into view—the peritoneum intervening—and twice because the gut was felt to be posterior, *i. e.*, to the vertebral side of the edge of the muscle. Tillaux (Traité d'Anat. Topog., fig. 210) figures the descending colon lying in front of the Quadratus Lumborum, and includes among the structures divided in the operation the Quadratus Lumborum. See also Braune, Topographical Atlas, pl. xvi. The author is desirous of making these statements, since some English writers direct the incisions for colotomy to be made on a line beyond the lateral border of the muscle.

[2] Ziemmsen's Encyclopædia, xv. 9.

[3] The fœtal position of the superior extremity with the arm adducted, the elbow flexed, the fingers semi-flexed or extended, and the thumb uppermost, may be assumed to be the best for the study of the subdivisions of the limb.

As in the relation of nerves to muscles, so in relation of nerves to skin, it is found that the regions occupied by extensor muscles (namely, the lateral regions) are more prone to localization of constitutional phases of disease than are the flexor surfaces. Such, for example, is the localization of the trophic lesions of leprosy. In ichthyosis the flexor aspects are exempt. From the circumstance that in inflammatory invasions of trunks of mixed nerves the motor filaments in the nerves resist the effects of morbid action longer than do the sensory, analgesic tracts of the lateral skin surface are often detected in the course of such diseases as Lepra nervorum (A. Nesser, Ziemssen's Handbuch. Haut-krankheiten, 1883, i. 622.)

The arbitrary division of the superficies of the superior extremity is based upon the conceptions of common life or upon considerations which are purely surgical in their applications. The position of the larger joints has been the standard. For general clinical purposes, especially for the student of neurology and dermatology, it is better to divide the limb into regions which are based upon the distribution of the superficial nerves. Thus the region of the Deltoid muscle is defined by the integument receiving the cutaneous branch of the circumflex nerve; the region of the arm from the Deltoid to the orifices of escape of the internal and external cutaneous nerves, and it is supplied by the lesser internal cutaneous nerve; and the remaining portion of the limb is supplied by the internal cutaneous, the external cutaneous, and the superficial branches of the radial nerves. The points of anastomosis of the cutaneous nerves are of clinical interest.—The arm may be divided into median and lateral surfaces, rather than anterior and posterior.

muscle is relaxed, the bursa can be felt on the anterior aspect of the tendon of the Biceps muscle.[1]

The *skin* over the region of the shoulder presents no features of interest. It is supplied by the cutaneous branches of the circumflex nerve and the suprascapular nerves. According to Hyrtl[2] (since the parts are covered with fasciæ which are continuous with fibrous dissepiments and these in turn continuous with the periosteum of the humerus), the region of the shoulder is peculiarly liable to rheumatic attacks.

THE REGION OF THE ARM.

The Region of the Arm may be said to be bounded above by the region of the shoulder and below by the region of the elbow-joint. The form of the region is determined by the humerus at about the surgical neck to a line joining the epitrochlea and epicondyle, and by the bellies of the Biceps, Coraco-Brachialis, and Triceps muscles, and the origins of the Supinator Longus, Extensor Carpi, Radialis Longior, and Extensor Carpi Radialis Brevior. The arm is obscurely prismoidal in figure in an athletic male adult, but is cylindroid in young women and in children. The arm presents a lateral and a median surface. The first named is limited proximally by the deltoid impression, while the second named joins the axilla. The following includes the chief surface markings. A depression at the insertion of the Deltoid muscle is on a level with the insertion of the Coraco-Brachialis muscle and the origin of the Brachialis Anticus. It is at this point of the shaft of the humerus that the angulation (see p. 175) sometimes exists, and at a point on the median aspect that the foramen of the nutrient artery of the shaft is situated. A depression answering to the position of the external intermuscular septum disappears abruptly at the origin of the Supinator Longus. It was formerly a favorite locality for the introduction of the seton. At its base the conspicuous supra-condyloid ridge can be felt. A median groove, the more pronounced of the two, corresponds in position to the main arteries and nerves of the arm, and is lost below in the anterior elbow-fold.

The epicondyle and epitrochlea are conspicuous processes at the lower part of the arm. The ulnar nerve lies close behind the epitrochlea. Both bony processes form favorable localities for fixation of bands in making traction on the humerus. The nerve is remarkably enlarged in this situation in trophic forms of leprosy.

A cluster of two or three small lymphatic glands lies on the median aspect a short distance above the epitrochlea. These glands are often enlarged in secondary syphilis, and may become inflamed in angeioleucitis.

The course of the brachial artery is best determined when the arm is moderately abducted and the forearm supinated. The artery then pursues an oblique course downward and outward. Above, it lies to the median side of the humerus; but below, it lies more to the front of the humerus.

The *skin* of the arm is very mobile, and permits the course of the larger veins to be outlined beneath it. It is thinner and more delicate upon the median than the lateral aspects. It is here that the effects of pressure, from ill applied surgical apparatus, is the most distressing. In the operation of rhinoplasty, after the method of Taliacozzi, the skin is secured from this region.

The skin of the arm is supplied on its median aspect as follows: the upper two-thirds by the branches of termination of the lesser internal cutaneous nerve and nerve of Wrisberg; and the lower fourth by the internal cutaneous nerve. The three cutaneous nerves pierce the fascia from in front a short distance above the elbow. The lateral aspect is supplied by branches of the circumflex and musculospiral nerves.

Small unimportant bursæ have been defined at the epicondyle and the epitrochlea.

THE ELBOW.

When the Elbow-joint is completely flexed the proximal third of the front of the forearm lies in contact with the distal third of the front of the arm. A conspicuous anterior skin-fold is created by this position which, if continued posteriorly, would intersect the epitrochlea and epicondyle, and which, when seen while the joint is semi-flexed, receives the name of the anterior skin-fold (*pli du coude*, plica cubitalis). The region of the elbow may be said to be inclosed in lines circling the arm for two fingers' breadth above and below this fold.

The following are the principal points of reference of the elbow. Seen from in front there is detected a lateral swelling, due to the Supinator Longus and the underlying Extensors of the Carpus. On the median surface is seen the less conspicuous eminence of the flexor mass. Between them is a V-shaped groove leading upon the arm to the bicipital grooves, and in common with them determined by the Biceps muscle.

[1] C. B. Nancrede, International Encycl. of Surg., ii. 709.

[2] Topog. Anat., ii. 294.

According to Hyrtl,[1] a bursa may be felt on this surface between the tendon of the Biceps muscle and the tuberosity of the radius which may attain the size of a walnut and be sufficiently dense to be taken by the observer for an exostosis. In favorably selected subjects the coronoid process may be felt in front of the joint when extended. The joint is not, strictly speaking, parallel to the axis of either the arm or the forearm, but exhibits an angle at the inner aspect of the joint by the intersection of these two lines.

Seen from behind, the olecranon and the position of the superficial bursæ are indicated. Both the superficial and the deep bursa may become sufficiently enlarged to form a conspicuous swelling in the living subject.

The *skin* of the elbow is thin and delicate anteriorly but thick posteriorly, and is everywhere free from hair except along the posterior surface. The anterior surface except in very fat persons is marked by superficial veins, especially when the arm hangs at the side. The skin possesses considerable reparative power, as is seen in the recovery from wounds and incisions. On the outer side of the olecranon is a dimple-like depression which is most conspicuous when the elbow is extended, and which corresponds in position to the head of the radius. The depression is bounded laterally by the Anconeus, and medianly by the Supinator Longus and the Extensor Carpi Radii muscles.

THE FOREARM.

The Forearm presents the figure of a club, whose base is proximal and rounded, and whose short handle is distal and compressed from side to side. The forearm lies between the lower limit of the region of the elbow (two fingers' breadths below the anterior elbow-fold), and the first of the transverse lines which form the proximal limit of the wrist on the anterior surface of the limb. The forearm exhibits a few eminences which answer to separate muscles even when they are at rest. On the anterior surface above the wrist are seen the tendons of the Palmaris Longus and Flexor Carpi Radialis. On the same surface when the wrist is slightly flexed, the tendons of the Flexor Sublimis Digitorum and the Flexor Carpi Ulnaris can be identified. When the thumb is held up and the ulnar border of the hand is depressed, the tendons of the Extensor Carpi Ulnaris and the Flexor Carpi Ulnaris can be felt distinctly above the wrist-joint. In forced extension of the thumb a slight fulness can be detected on the lateral surface of the forearm over the position of the origin of the Extensor Ossis Metacarpi Pollicis muscle. The remaining muscles of the forearm give bulk to the forearm and more especially form the rounded, firm, cushion-like masses, which embrace the bones at the proximal two-thirds. The chief muscular mass is placed in front rather than back of the radius and ulna.

The head of the ulna and the median margin of the shaft can be felt as well as the lower two-thirds of the shaft of the radius including the styloid process.

The *skin* is delicate and smooth in front, but thick behind. It is much less mobile than in the arm. The posterior surface is, in the male, covered with hair.

THE WRIST.

The region of the Wrist is defined by a space two fingers in breadth, above and below the line of the wrist-joint. It is in a general way limited by the linear depressions which answer to skin-folds on the anterior surface of the wrist.

The anterior or flexor surface is subdivided into two subregions, the radial and the ulnar. The *radial subregion*, the smaller of the two, lies between the tendon of the Extensor Ossi Metacarpi Pollicis and the Flexor Carpi Radialis. The pulsations of the radial artery can be felt in this region. The *ulnar subregion*, owing to the smaller bony surface underlying it, as compared to the radial, is cushion-like. It lies between the Flexor Carpi Radialis and the Flexor Carpi Ulnaris. Conspicuous in this region is the tendon of the Palmaris Longus.

The extensor or dorsal surface extends from the Extensor Ossi Metacarpi Pollicis to the tendon of the Flexor Carpi Ulnaris. It thus embraces both the radial and the ulnar borders of the region. The space between the Extensor Ossi Metacarpi Pollicis and the Extensor Secundi Internodii Pollicis (radial fossa, *tabatière anatomique*) is best seen when the muscles are contracted, and answers to the position of the scaphoid bone and the trapezium.—The ulnar border is most pronounced in supination.—When the wrist-joint is semiflexed the cuneiform bone can be felt lying to the lateral aspect of the movable pisiform bone. Between the ulnar and radial borders, when the fingers are extended, the tendons of the Extensor Communis Digitorum can be felt; the Extensor Minimi Digiti can be detected when the little finger is extended;

[1] Topog. Anat., ii. 289.

and the Extensor Carpi Ulnaris when the hand is turned downward, while the thumb is held up.

A knife thrust inward beneath the styloid process of the ulna will enter the wrist-joint, but one thrust inward below the styloid process of the radius will strike the scaphoid bone.

The *skin* is thin, delicate, and smooth over the anterior aspect of the joint, but is hairy and thicker, and less mobile over the posterior.

THE HAND.

The Hand embraces that portion of the superior extremity which is placed distally to the wrist. The sides of the wrist expand abruptly to be continuous with those of the hand. The hand is divided into

The Body of the Hand.
The Fingers.

The Body of the Hand presents an anterior surface, a dorsal surface, and two borders, the radial and the ulnar.

The Anterior Surface (palmar surface, the palm), is quadrangular in form, and is slightly larger than the dorsal. On this surface can be felt, in addition to the muscles named below, the Adductor Pollicis, the Abductor Indicis, and the tendons of the Flexor Sublimis Digitorum. It is subdivided into the thenar and hypothenar eminences, the transverse pad, and the "hollow of the hand."

The *thenar eminence* (ball of the thumb) is the name given to that eminence which corresponds to the Abductor Pollicis, Opponens Pollicis, and Flexor Brevis Pollicis muscles.

At the proximal base of the thenar eminence can be felt the tubercle of the scaphoid bone and the ridge of the trapezium. The sesamoid bones of the thumb can also be distinguished in some subjects.

The *hypothenar eminence* is that eminence over the Abductor Minimi Digiti, the Flexor Brevis Minimi Digiti, and the Opponens Minimi Digiti muscles. To the inner side of the base the pisiform bone can be felt. —The thenar and hypothenar eminences sometimes receive the name of the *heel of the hand.* The skin uniting the two eminences overlies the deep annular ligament.

The *transverse pad* of the palm is a thick cushion of skin and subcutaneous fat which answers to the position of the head of the metacarpal bones, and the proximal portions of the phalanges of the first row. In front at the "interdigital spaces" the transverse pad enters into the composition of the web of the fingers. The form of the *web of the fingers* is maintained by the superficial transverse ligament. The transverse pad is marked opposite the web by three small pulp-like elevations, which answer, during forced flexion of the fingers, to the interdigital spaces between the second and third phalanges. The pad becomes flattened in extension of the fingers, but is conspicuous, and serves to deepen the hollow of the hand, in flexion.

The *hollow of the hand* is that triangular depression whose apex is directed proximately, and which intervenes between the thenar eminence, the hypothenar eminence, and the transverse pad.

The Dorsal Surface of the body of the hand is bounded proximally by the wrist, and distally by the web of the fingers. On this surface can be felt the shafts and heads of the metacarpal bones, the positions of the Dorsal Interossei muscles, and the tendons of the Extensor Communis Digitorum muscle.

The *skin* of the body of the hand is thin over the thenar eminence, where it has supplied the flap in rhinoplastic operations, but thick elsewhere on the anterior aspect, while it is uniformly thin over the dorsal.—The skin of the palm is not subject to superficial abscess, as is that of the dorsum. Bursæ are not rare over the dorsal aspect of the metacarpo-pharyngeal articulations.

The skin-creases. The motions of the hand, which enter into the study of the skin-creases, are flexion and extension of the hand on the wrist and the fingers on the hand; and abduction and adduction of the thumb on the body of the hand.

The first crease lies at the junction of the thenar eminence and the hollow of the hand, and forms an oblique curved line, whose convexity is directed inward. It is determined by the motion of the metacarpal bone of the thumb toward the palm. The second crease is transverse, and answers in position to the metacarpo-phalangeal articulation of the index finger. It is pronounced at the radial border of the body of the hand, but becomes faint and disappears as it reaches the hypothenar eminence. The third crease is occasioned by the flexion of the third, fourth, and fifth metacarpo-phalangeal articulations. It is pronounced at the ulnar border of the body of the hand, and terminates at the position of the head of the second metacarpal bone.—The convexity of the superficial palmar arch lies, as a rule, in the space between the two transverse creases.—A number of secondary skin-creases mark the palm. Several of them lie in groups of small oblique lines, which are seen upon the ulnar side of the hypothenar eminence. One of these inter-

sects the transverse lines, and with them forms a fancied resemblance to the letter M. A second group lies in clusters upon the transverse pad, in the axial line of the metacarpal bones.

The Fingers. Each finger presents an anterior (palmar) surface, a posterior (dorsal) surface, and two lateral surfaces. The spaces between the fingers have received the name of the interdigital spaces. The space between the thumb and the index finger is spoken of as the "crotch of the thumb."

The fingers present a compact integument over the anterior, and a thin integument over the posterior surface. Transverse skin-folds mark the lines of flexion of the second and the third row of interphalangeal articulations, and, on the palm, between the proximal third of the first row of phalanges and the transverse pad of the palm. These folds lie on a line uniting the "web of the fingers."

THE INFERIOR EXTREMITY.

Unlike the shoulder, the hip embraces all the structures that are intermediate between the exsert and trunkal portion of the limb; it is again unlike, in being rigidly fixed to the framework of the trunk.

An account of the superficial anatomy of the lower extremity will be described under the following titles:[1]—

The Hip.
The Groin.
The Thigh.
The Knee.
The Leg.
The Ankle.
The Foot.

THE HIP.

The Hip[2] (gluteal region, region of the buttock), is semicircular in form, and is defined above by the crest of the ilium; below by a horizontal line, which corresponds to the lower border of the tuberosity of the ischium; medianly (*i. e.*, toward the vertebral column) by the depression over the sacrum (sacral groove); and laterally, by an imaginary line, extending from the anterior superior spinous process of the ilium, to the great trochanter. This region is flat in the infant and in weak adults. It is convex in well-nourished subjects, and is especially full and rounded in females.

The upper third of the region is flatter, where it corresponds to the Gluteus Medius, than the lower two-thirds, where it corresponds to the Gluteus Maximus. The anterior border is on a line with the Tensor Vaginæ Femoris.

The *skin* of the posterior region of the hip is thick and brawny. It cannot be raised in folds with readiness, but the entire surface can be moved in a moderate degree, from side to side. It is a favorite locality for furuncles.

The skin at the line of the crest (iliac furrow) of the ilium is held well down to the bone, and forms in muscular individuals a well-defined depression. A marked depression overlies the trochanter major. A conspicuous fold (gluteal fold) corresponds to the lower margin of the Gluteus Maximus muscle when in a state of tonic contraction.—The gluteal fold is obliterated in the first stage of coxalgia, for the reason that the function of the Gluteus Maximus, in keeping tense the fascia lata, is suspended, and that the flexor muscles of the femur move the thigh slightly forward. The fold is a guide to the space beneath the Gluteus Maximus, and may be used as a point for the evacuation of blood and pus.—When the sciatic nerve is thickened, as in sciatica, it can be felt by deep palpation beneath the gluteal fold.

Four bursæ are enumerated in the region of the hip. The first is superficial, and lies between the skin and the tendon of the Gluteus Maximus muscle, as it glides over the trochanter major; a second is deep-seated, and lies between the tendon of the Gluteus Maximus and the trochanter major; a third is beneath the Gluteus Maximus and the tuberosity of the ischium; and a fourth, inconstant, is over the sacro-coccygeal articulation. All of these bursæ may become enlarged, and can be detected in the undissected subject. The first-named may become distended, and be in part occupied by barley-like nodules, or may suppurate; the second, may suppurate, and from its intimate association with the bone lead to caries; the third, may become moderately enlarged, and in the aged exhibit enormously thick-

[1] It is more difficult to arrange the surface of the lower extremity into natural regions than it is in the case of the superior extremity, for the reason that the entire limb is to a greater extent a natural region. The Gluteus Maximus and Tensor Vaginæ Femoris muscles, since they make tense the fasciæ of the thigh, and since the integument over them is supplied by the terminal branches of the posterior divisions of the lumbar nerves, may constitute a natural region (the posterior region of the hip of the text); the posterior surface of the thigh, which corresponds to the distribution of the branches of the small sciatic nerve, a second; the anterior surface of the thigh, which corresponds to the distribution of the terminal branches of the anterior division of the lumbar nerves (excepting the long saphenous nerve), a third; the posterior surface of the leg, and the lateral margin of the foot, a fourth; the median aspect of the leg, a fifth; the lateral aspect of the same, a sixth; and the dorsum of the foot, the region of the musculo-cutaneous nerves, a seventh; and the sole, an eighth.

[2] The region of the hip is restricted by Tillaux to the region about the hip-joint.

ened walls, and be traversed by bands; and the fourth, has been described by Luschka and Hyrtl as susceptible of enlargement. The writer last named suggests that when this bursa is found enlarged in infants, it should be studied in connection with the appearances of spina bifida, of which, when imperfectly developed, it may be a related defect.

The points that can be distinguished by palpation in this region are the crest of the ilium, the anterior and posterior superior spinous processes (the last named being on a level with the second sacral spine), the prominence over the sacral spines and over the great trochanter, as well as a depression directly behind this eminence.

The space between the Gluteus Maximus and Gluteus Medius is sometimes the seat of blood extravasation and of abscess. Fistulæ may also point here. As a rule it may be said that the affections of this region are initiated elsewhere, either in the cavity of the pelvis (from which space they may involve the region of the hip through the sacro-sciatic foramina), or in the bones.

By Nélaton's line is meant an imaginary line extending from the anterior superior spinous process of the ilium to the centre of the tuberosity of the ilium.

THE GROIN.

The Groin[1] (inguinal region, trigonum inguinale, upper femoral region) is that space which is defined upon the anterior surface of the thigh by Poupart's ligament above, by the continuation of a line which unites the lower limit of the femoro-scrotal with the gluteal fold below; and, to the outer side, by an imaginary line which extends between the anterior superior spinous process of the ilium and the great trochanter.

The groin is thus a triangular space which answers to the lines of voluntary flexion of the thigh on the abdomen. The lower limit corresponds to a line uniting the points of exit of the middle cutaneous and the small sciatic nerves.

The *skin* of the groin is thin and delicate and at the median third is covered in the adult with hair; toward the pubis the skin is furnished with numbers of sweat and sebaceous glands, is liable to attacks of intertrigo, and may be involved in eczema of the genitals and the perineum. As a rule, the skin is translucent, and permits the course of the superficial veins to be discerned beneath. In cicatricial contractions, the skin may aid in maintaining states of morbid flexion of the thigh on the abdomen. While mobile and distensile, and readily accommodating hernial and fatty tumors, the skin may be torn on sudden forced extension of the thigh from a position of previous flexion.—It may resemble that of the abdomen in women who have borne children.—Skin-incisions gape more when transverse than when vertical; hence it has been recommended by Malgaigne to open abscesses by vertical incisions.

The following structures can be detected by touch in the groin. Poupart's ligament can be felt at the bottom of the depression which extends from the anterior superior spinous process of the ilium to the spine of the pubis. The outer half of the ligament is the more distinct. The ligament is relaxed in flexion of the thigh on the abdomen, and on flexion and adduction of the thigh.—The inguinal lymphatic glands can be detected, especially in thin young subjects.—The bursa beneath the conjoined tendon of the Iliacus Internus and Psoas Magnus muscles is sometimes sufficiently distended to be felt. When thus abnormally enlarged, it may be mistaken for psoas abscess.—The pulsations of the femoral artery can be felt. Pus from a psoas abscess and hernia through the obturator foramen readily involve the inguinal region.

THE THIGH.

The Thigh includes that region which lies between a line encircling the limb at the gluteal fold, and a second line, at the upper margin of the *cul-de-sac* of the knee-joint, when the thigh is extended. The line last named encircles the limb one-and-a-half inch above the patella.

The thigh is cylindroid in form in well-nourished females and infants, but it is less regular in form, and is marked by numbers of eminences in muscular adults, in whom the thigh is rounded on the lateral and posterior surfaces, is slightly convex on the anterior, and is flat upon the median surface. The form of the thigh is due to the shaft of the femur at a portion which answers to the linea aspera and to the deep fascia which incloses the muscular masses.

The *skin* is thicker upon the lateral than upon the median aspect. It is everywhere freely movable, but is especially mobile over the outer hamstrings and along the lower median surface. In well-nourished infants the skin is marked by several transverse folds, which may become the seats of intertrigo. —Varicose veins are not unfrequently seen beneath

[1] The groin is, in common language, the depression between the abdomen and the thigh, while the inguinal region pertains to the iliac region of the abdomen as the term "inguinal canal" would indicate. While the two terms are thus not, strictly speaking, synonymous, they are interchangeably used in clinical reports.

the skin of the anterior surface.—The skin of the lateral surface is often perforated by fistulous tracts in necrosis of the shaft of the bone.

The following points can be detected in the thigh: A band of fascia lata can be felt extending below the Tensor Vaginæ Femoris; this band is most pronounced in emaciated males, and forms near the trochanter, and near the knee-joint, a conspicuous line beneath the skin. The eminences of the Vasti muscles, the Rectus Femoris, and (when the leg is flexed and adducted) the belly of the Sartorius muscle, on the front of the thigh; the adductor mass, especially the Adductor Longus, on the median surface; the tendon of the Biceps Femoris on the lateral border; and the tendons of the Semimembranosus and Semitendinosus on the median border of the posterior surface. — A well-defined depression ordinarily exists on the upper aspect of the thigh between the Rectus Femoris and the Adductor mass.

THE KNEE.

The region of the Knee is defined proximally by a line encircling the limb at the upper border of the *cul-de-sac* one-and-a-half inch or two fingers' breadth (rarely two inches) above the patella, and distally by a line encircling the limb immediately below the tubercle of the tibia.

The region of the knee is smaller than that of the thigh or the leg, and exhibits but little disposition to the accumulation of fat. It is relatively larger in children than in adults, and in rachitic than in normal subjects.

The region of the knee is divided into two regions: the anterior, and the posterior.

The Anterior Region is subpyramidal in form; the sides of the figure are composed of the lateral and median surfaces of the joint and their overlying structures, where the summit is represented by the patella. It receives more accessions from the fascia lata than does the posterior region.

The *anterior surface* (front of the knee). The patella forms the most conspicuous feature of the anterior surface. This bone is freely movable from side to side in extension, but is fixed against the femur in flexion. The median border is better outlined than the lateral. The edges of the inter-condyloid notch can be determined. Below the patella the position of the ligamentum patellæ can be ascertained. A shallow depression is seen on each side of the ligament in slender subjects, but, in the well-nourished, there is seen at this point a convex surface due to the presence of a quantity of underlying fat. In chronic diseased conditions the serous exudation into the fat of this region causes the masses to become exceptionally prominent, and to constitute an important feature in the superficial appearance of the joint. Care should be taken not to confound the soft, yielding character of these swellings with abscess.

The bursæ, which may be determined by palpation, are two in number. The first and most important lies directly in front (covering the lower two-thirds) of the patella. When enlarged it constitutes "house-maid's" knee, and may be the size of an egg or small orange. It may suppurate and even lead to caries of the patella. The second bursa lies beneath the ligamentum patellæ, as this structure is attached to the tibia. It is less frequently enlarged than is the prepatellar bursa. Hyrtl describes a bursa (pretibial bursa) lying in front of the tubercle of the tibia and of the ligamentum patellæ. It is acquired, and thus differs from the two foregoing.

The extension of the synovial membrane, above the patella, determines a point at which the synovial chamber can be punctured. It is recommended to insert the instrument a little above and to the median side of the patella.

The *skin* of the anterior region is thicker and rougher over the patella than at the sides of the joint, and in extension in many subjects is thrown into a number of minute transverse folds.

The *lateral surface* (external surface, outer side of knee) is flat or slightly concave. The external condyle of the femur, the tuberosity of the tibia, the interarticular depression between the femur and the tibia, and the edge of the interarticular disk can be distinguished. A fold of fascia lata, which corresponds to the line of traction of the Tensor Vaginæ Femoris, is pronounced in extension. The external lateral ligament can be distinguished.

The *median surface* (internal surface, inner side of knee) presents more conspicuous bony prominences, but less pronounced fibrous structures, than does the external surface, but on the whole it is less sharply defined. Thus the general surface is convex from the projections of the internal condyle of the femur and the internal tuberosity of the tibia, while the interarticular depression is imperfectly defined, and the ligaments and bands of fascia lata are absent. The Adductor Magnus tubercule for the tendon of insertion of the muscle of the same name, can be felt a short distance above the internal condyle, where it corresponds

to the line of epiphyseal junction. The lower part of the Vastus Internus muscle can be determined.

The Posterior Region[1] (ham, back of knee) is hollow in flexion, but is flat or even convex in extension. The boundaries of the posterior region are best seen when the knee is semiflexed. They are then well defined by the tense folds which answer to the tendons of the hamstring muscles. The lower half of the popliteal space is less distinctly outlined, and answers to the soft yielding mass lying between the prominence of the head of the tibia and the head of the fibula.

The depression between the hamstrings is the *hollow of the knee* (popliteal fossa, sulcus poplitei).

The tendon of the Biceps can be easily distinguished at the outer border, and, in semiflexion, the external popliteal nerve also lying to its median side. In the same position of the joint the internal popliteal nerve can be felt in the median line at the centre of the ham. In yet deeper palpation the popliteal artery can be often felt pulsating. Along the median border the tendons of the Semitendinosus, the Semimembranosus, and the Gracilis can be easily determined.

Small superficial lymphatic glands can be distinguished beneath the skin in young strumous subjects. Owing to the dense fascia covering the joint posteriorly, the parts beneath the fascia can be imperfectly if at all defined. The deep lymphatic glands when enlarged form diffuse swellings of the ham. Collections of pus here tend to pass up or down the limb, or even into the joint rather than toward the surface.

The *skin* of the posterior region is delicate, and marked by a transverse crease at a point a little above the interarticular line. It may be greatly distended to accommodate a tumor or an aneurismal sac. On the other hand, it may contract in long-continued flexion of the joint, and has been known to rupture as a result of sudden and forced extension. The fat of the posterior region is more abundant than in the anterior, and may become the seat of abscess.

The bursæ of the posterior region are found on both the median and lateral borders, but are smaller and less constant along the lateral. An enlarged bursal swelling occurring between the tendon of the Biceps, and the external popliteal nerve, may be identified with the bursa normally present between the tendon of this muscle and the external lateral ligament. The bursæ that can be detected along the median border are commonly confined to the space between the inner head of the Gastrocnemius and the tendon of the Semimembranosus. They may communicate with the joint. In the middle of the posterior region, the hernial protrusions of the synovial membrane may occur of sufficient size to be determined by manipulation. For the most part they can be distinguished from enlarged bursæ, not only from their position, but from the fact that in semiflexion gentle pressure will cause the tumors to disappear.

[1] For boundaries of the popliteal space, see p. 406.

THE LEG.

The region of the Leg is defined proximally by a circular line which embraces the limb at the level of the tubercle of the tibia, and distally, by a second which encircles the limb directly above the malleoli.

The general form of the leg is conical, the base being upward. It is smooth and uniformly round in children and in women, but is irregularly prismoidal in men.

The leg is roughly divided into a muscular proximal two-thirds, and a distal tendinous one third. This division, while not exact, will serve to separate the bulky parts of most of the muscles of the leg from their tendons, as they lie within this region. The line of such a division nearly corresponds to the point of escape of the musculo-cutaneous nerve from the deep fascia.

The *skin* throughout is more adherent to the fascia than is the case in the thigh, and is in addition contrasted with that portion of the integument in being in close relation to both the tibia and the fibula for considerable portions of their length. Beneath the skin a sparse layer of fat is deposited anteriorly, but becomes thicker posteriorly.

Accepting the prismoidal form as typical, the leg exhibits three surfaces: an anterior, a lateral, and a posterior surface.

The *anterior surface* (antero-median region, region of the "shin") corresponds to the anterior surface of the tibia, and to the course of the anterior tibial vessel and nerve. At the upper portion, just below the tubercle of the tibia, the elongated swelling of the belly of the Tibialis Anticus can be felt, and to its outer side the belly of the Extensor Longus Digitorum. At the lower portion, immediately above the internal malleolus, especially when the ankle is flexed and the toes extended, the tendons of these muscles, together with the tendon of the Extensor Proprius Pollicis, can be felt as they lie along the tibia. The intermediate portion of the anterior surface is marked by the crest of the tibia, which can be thus felt, for nearly the entire length of the leg, as a sigmoid curve. To the outer side the corresponding anterior surface—

the "shin," of common language—can be defined. In rachitic subjects this surface is uniformly convex.—The *skin* is firmly adherent to the underlying parts.

The *lateral surface* (peroneal region, antero-lateral region) is defined by the fibula, and answers to the location of the Peroneal muscles, peroneal vessels, and the external popliteal nerve. The position of the bone can be obscurely felt throughout. Above, the head can be readily distinguished, and below, namely, at its lower half, where the bone lies beneath the integument, the anterior surface can be easily outlined. The muscular mass about the upper half of the fibula corresponds to the Peroneus Longus and the Peroneus Brevis muscles.—The skin over the lateral region is more hairy than elsewhere on the leg.

The *posterior surface* is convex and broad. It is less pronounced in the negro than in the white race, and answers for the most part to the bulk of the Gastrocnemius and Soleus muscles. The inner longer head of the muscle first named can be easily distinguished. Toward the ankle the tendo Achillis forms a conspicuous feature. To the inner side of the tendon the posterior tibial artery can be felt pulsating, and the position of the tendons of the Tibialis Posticus and Flexor Longus Digitorum can be determined.—The *skin* of the posterior region is thinner, softer, and more yielding than upon the anterior or the lateral surfaces. The course of the short saphenous vein can often be noted.

THE ANKLE.

The Region of the Ankle is defined above by a line uniting the bases of the malleoli, and below by a line drawn round the limb at a point about half an inch below the malleoli; behind at a point on a level with the attachment of the tendo Achillis, and in front, about an inch in front of the lower extremity of the tibia. The region thus corresponds to that of the union of the tibia, fibula, and astragalus with one another, and embraces in addition the region of the head of the astragalus.

The ankle is remarkable for the absence of muscle tissue about it. It is of great strength behind and at the sides, but is weak in front.

The ankle is divided into an anterior, a posterior, a lateral, and a median surface.

The *anterior surface* (front of ankle) is marked from within outward, in the order in which they are here mentioned, by the tendons of the Tibialis Anticus, Extensor Proprius Pollicis, the Extensor Communis Digitorum, and the Peroneus Tertius muscles. These tendons are readily distinguished; that of the Tibialis Anticus is the most conspicuous, and that of the Extensor Communis Digitorum answers to the middle line of the surface.—When the foot is fully extended, the convex surface of the anterior capsule of the joint can be felt lying between the internal malleolus and the tendon of the Tibialis Anticus.

The *skin* is smooth and delicate. It is thrown into a number of transverse creases in flexion.

The *posterior surface* (back of ankle) is marked by the prominent tendo Achillis. The upper portion of the tendon answers to the inter-articular line, on either side of which structure a hollow space is defined. The posterior tibial artery can be felt pulsating in the centre of the median hollow. The tendon of the Tibialis Posticus can be distinguished behind the internal malleolus in adduction of the foot. In synergic contractions of the Extensor Proprius Pollicis and the Flexor Longus Pollicis, a swelling appears in the median hollow which can be referred to the muscle last named. In flexion the outline of the deltoid ligament can be determined. In the lateral hollow can be felt (best in abduction and pronation of the foot) the tendons of the Peroneus Longus and Peroneus Brevis muscles.

The *skin* of the posterior surface is a little thicker than in front, and is freely movable over the tendo Achillis. Fat is abundant in the hollows at the sides of the tendon, but is nearly absent over the tendon itself. The bursa between the tendon and the calcaneum is sometimes distinguishable.

The *lateral* and *median surfaces* (sides of ankle) answer to the spaces over the malleoli, and present few points of interest beyond the outlines of the malleoli themselves, which are bold and distinct. The internal malleus, while broader than the external, is less prolonged inferiorly, and is set a little more forward. The internal malleolus is obliquely placed to the axis of the tibia, while the axis of the external malleolus is in the same line as the longitudinal axis of the fibula.

THE FOOT.

The foot is that portion of the inferior extremity which is placed distally to the ankle-joint. But since the region of the ankle-joint is already defined, it is convenient to restrict to the foot that region placed in advance of a line drawn round the limb half an inch below the malleoli. The foot, as a whole, joins the leg at nearly a right angle.

The Region of the Foot is divided into—

The Tarso-Metatarsal Region.

The Region of the Toes.

The Tarso-Metatarsal Region (posterior region) presents a dorsal and a plantar surface.

The *dorsal surface* is smaller than the plantar, and is arched to correspond to the general form of the bones of the tarsus and of the metatarsus.

The belly of the Extensor Brevis Digitorum forms a soft, cushion-like mass on the lateral aspect of the dorsal surface, and exhibits, owing to the unyielding bony surface beneath it, a sensation resembling that of fluctuation, which has misled incautious practitioners to believe that a collection of fluid existed beneath the skin.

The *skin* of the dorsal surface is delicate, and is imperfectly adapted to bear the pressure of surgical appliances.

The general shape of the neck of the astragalus can be outlined when the foot is fully extended.

The *plantar surface* (sole), excepting along the lateral border, where it is flat, presents the form of a low arch (hollow of the foot), whose posterior buttress is represented in the heel, and whose anterior buttress constitutes the "ball of the toes."

The *skin* of the plantar surface is of great thickness, having an average of three lines, though it is much thicker and of callous consistence under the heel. It is also thicker than the average, but more elastic than elsewhere over the "ball of the toes." The structure last named extends across the sole in a position analogous to that occupied by the transverse pad in the hand. The "ball of the toes," as the name expresses, supports the toes at their basal portions as well as the body of the foot, and corresponds nearly to the proximal three-fourths of the first row of phalanges.

The skin of the arched portion of the sole is relatively thin, and possesses tactile sensibility in a high degree. The lips of an incision made in the skin of the plantar surface gap to a less degree than those made upon any other portion of the integument of the body.

The median border of the plantar surface merges insensibly into that of the ankle and of the dorsal surface. It presents from behind forward the following points: The tuberosity of the calcaneum, the sustentaculum tali, the head of the astragalus, the calcaneo-scaphoid ligament, and the tendon of the Tibialis Posticus muscles which, according to Chopart, in old subjects may present near its insertion a fibrous nodosity which may be mistaken for the tubercle of the scaphoid bone lying directly in front. The tubercle last named is found one-and-a-half inch in front of the internal malleolus. Next in order are felt the first cuneiform bone, the sesamoid bones of the Flexor Brevis Pollicis muscle, the base of the first metatarsal bone, and finally, the head of the bone last named.

The lateral border from before backward exhibits the perineal tubercle (in exceptional instances this may be large and hook-like) between the Perineus Longus and Perineus Brevis tendon, the tendons of the muscles last named themselves, the anterior end of the calcaneum best felt when the foot is everted, and the conspicuous base of the fifth metatarsal bone. The cuboido-calcaneal joint lies eight lines back of this process.

The soft cushion-like mass which adjoins the median border is due to the Abductor Pollicis and Flexor Brevis Pollicis muscles.

The analogous mass lying along the outer border is due to the Abductor Minimi Digiti and the Flexor Brevis Minimi Digiti muscles.

The general outline of the plantar fascia can in part be determined as it lies between these two masses.

The body of the foot is the seat of a number of acquired bursæ, the positions of which are determined by valgus, varus, and by certain occupations.

The Region of the Toes (anterior region) presents a plantar and a dorsal surface. The plantar surface of each is concave from before backward, but convex from side to side, and is marked by transverse creases which correspond in position to the interphalangeal joints. Each terminal phalanx is convex and club-shaped.—The apposed surfaces of the toes are flat and join the dorsal surface by angulated borders.—The dorsal surface of the toes exhibits a delicate skin, which resembles that of the dorsum of the tarso-metatarsal region.

The first or great toe is in a line with the median border of the tarso-metatarsal region. It is commonly deflected outward in adults at the tarso-phalangeal joint, owing to the long-continued pressure of ill-fitting shoes, though such deviation may be the result of interstitial arthritic change. The median surface of the articulation is often the seat of an inflamed bursa having callous walls (bunion).

The second toe is a little longer than the first. It is often treated conventionally by sculptors as somewhat shorter than the first. The fifth or little toe has a marked motion in abduction. It is commonly deformed by pressure of the shoe.

EMBRYOLOGY AND THE STUDY OF MALFORMATIONS.

EMBRYOLOGY treats of the development of the embryo.

Since the chief interest which the physician finds in this science is the detection of relationships which exist between normal and abnormal processes, it is proposed in this chapter to give a brief outline of those phases of embryology which may be held to be useful in studying congenital defects. The object of such a study is to determine how far the laws of morphology can explain the aberrant structures of the human body, and to distinguish between such structures and the results of diseased action.

The study of congenital defects is included under Teratology. Literally interpreted, teratology is that science which treats of *monsters;* and, as originally proposed by Etienne Geoffroy St. Hiliare,[1] it treats of subjects in which are exhibited more than a single gross malformation. According to the same authority, specimens showing but a single defect are not to be considered as monsters, but as examples of *anomaly*.

This distinction never came into general use, and the terms *monster* and *anomaly* are now almost interchangeably employed. Neither the one nor the other term is accurate; for the term monster is simply a survival of a superstitious idea respecting the origin of a subject which may chance to exhibit gross defects; while no defect whatsoever can be considered an anomaly, since all so-called "anomalies" can be explained (if explicable at all) by the operation of those laws the effects of which are seen in the normal development of the organism.

The term *variation* expresses the unusual disposition of the parts of an organ or system of related structures. Variations have been more carefully studied in the osseous, muscular, circulatory, and nervous systems than elsewhere in the body. Unlike the subjects of "teratology" and "anomaly," "variations" may be both congenital and acquired.

The range of congenital variation in a given organ, and the relative rate of variations in different portions of the body are important subjects for investigation. In a general way it may be said that the most plastic structures are either those which have retained to the greatest extent the formative peculiarities of the embryo (as, for example, the ovary), or those which have been added last in the processes of differentiation, as the occipital lobe of the cerebrum, the spleen, the thyroid body, etc.

The study of variation of an anatomical object, broadly considered, not only embraces the departures from a standard description, which is simply the average drawn from numbers of observations, but includes all structural phases of the life-history of the object under consideration. By it are implied, in addition, its modifications peculiar to sex, as well as its manner of responding to the impress of diseased action.

Among the acquired variations may be mentioned the shapes of the skull as dependent upon rates of brain-growth; the deviation of the nasal septum; the increase of planal cleavage in the muscles of athletes; the changes in the form of a bone by muscle-traction; the shape of the jaws in those persons who habitually breathe through the mouth; the deformation of the thorax dependent upon changes in rates of respiration; and the elevation of the aortic arch by increase of the action of the heart.

For the most part all accounts of variations in this book are appended to the descriptions of the organs in which they occur.

The Causes of Malformation.—In the early history of the embryo, malformation may be caused by violent agitation of the germ, by abrupt changes in its temperature, by the effects of inflammatory processes (*infra*), and by injury. The direct and immediate effects of any of these causes are often distinct from the indirect and subsequent effects. Thus a band of inflammatory adhesion between the amnion and the integument may distort superficial structures which appear thereafter in the entire region in which the adhesion occurs. In like manner intra-uterine fracture of the femur may distort the tibia and the fibula, invert or extend the foot, and reduce the number of the phalanges. Many of these effects are probably reflex phenomena, or those pertaining to the trophic influence of nerves.

Inflammatory effects are of two kinds: First, the effect upon the nutrition of a part by a thrombus, which has

[1] The numerous memoirs of this author (in the Comptes Rendus and Mus. d'Histoire Naturelle) extend over a period of twenty years, 1821–1840; see, also, Philosophie Anatomique, Paris, 1822.

been detached from a remote area of inflammation, and which thus obstructs an artery in a given region, impairs the rate of its development and growth; in this manner an endocarditis of the right side of the heart may be associated with absence of the right kidney, as a result of obstruction with a thrombus of the corresponding renal artery.—Second, the bands of union already mentioned between the amnion and the integument. These appear to be more common about the face than elsewhere. Förster[1] has figured symmetrical bands, which were attached to both eyes, and a single band[2] which extended from the mouth upward along the left side of the face. Similar methods of attachment may be associated with imperfect development of the face.[3]

The class of malformations in which parts are duplicated or are present in excess may also in part be explained by trophic action of nerves, since it is understood that in rapidly growing tissues a disturbance in the normal relation existing between a given structure and the nerves supplying it will terminate not in atrophic but in hypertrophic conditions.

Many examples, however, as in symmetrical duplication either of a part of the embryo or of the entire fœtus, cannot be so explained. As aids to the study of such conditions, the laws of morphology, as these are defined in the structures of animals and plants, are of importance.

The mental attitude of the mother toward her offspring is often dwelt upon as a powerful factor in creating malformation; but while it cannot be discarded, it rests upon a less satisfactory basis than any of the general causes already outlined.—In a general way it can be said that all gross defects are examples of the manifold effects of malnutrition. Animals artificially raised or domesticated are more liable to have defective offspring than are those which can determine for themselves their surroundings; and human defects are more common among impoverished than among well-nourished individuals.

The correlations of deformities one to another indicate the harmonies present between the several parts of an organism. It has been found, for example, that cleft-palate and single kidney are often associated. Defects of the hairs are apt to be associated with defects of the teeth and of the nails. Congenital defects of the œsophagus and the respiratory apparatus, and of the deeper veins and the degrees of lobulation of the lungs, are often related. Parts arranged in serial order as the vertebræ, the several parts along an embryonic rod as a visceral arch, are commonly multiple. A nerve-centre, such as a motor-centre of the cerebrum, will modify the area controlled by that centre. In like manner, absence of the olfactory nerve and its cerebral tract will violently disturb the formative processes of the region to which the peripheral filaments are normally distributed.

The brain exerts a profound influence over the etiology of malformation. A tendency to cerebral precocity is found by D. Hunt to be associated with myopia. It is probable that the absence of myopia in the negro as determined by S. D. Risley is a correlation with the low rates of cerebral development in this race. It is also probable that true asymmetry of the nasal chamber has a similar causation.

According to Lawson Tait,[1] geographical situation has much to do with the relative frequency of cleft palate. He instances the curious fact that all lion whelps born in the London Zoological Garden have cleft palate, while in other gardens this deformity is unknown. In some districts of Yorkshire, cleft palate would seem to be endemic, and is not merely a family peculiarity.

One of the most important correlations in embryology is that existing between the internal and external conditions of many parts of the body. The elements of the derm and epiderm appear to be under the trophic control of the deeper organs which they are intended to protect. Defects of the bladder correlate with defects of the skin over the region of the bladder; spina bifida, with the skin over the affected part of the vertebral column; a defect of the olfactory lobes or tracts, with the skin of the external nose, etc. In defects of the ovaries and testes, the external organs of generation are always in sympathetic relation.

It is an open question to what extent a malformed fœtus can be designated a genus, or to what degree the subdivision of each genus may receive the name species. So long as naturalists are not agreed as to the restriction of these terms in normal plants and animals, no exact premises can be presented by which the subject can be rationally discussed. A classification of monsters based upon the laws of development and the causes exciting aberration would, all things remaining equal, be the most satisfactory; but, in the absence of the data warranting such an attempt, it has been thought best to employ the nomenclature which has been sanctioned by custom. Isidore Geoffroy St. Hiliare[2] has proposed a classification of gross congenital defects based upon the prin-

[1] Misbildungen, Pl. xxv. fig. 31.
[2] Ibid., Pl. xviii. fig. 31.
[3] Ibid., Pl. xv. fig. 22.

[1] Steiner's Compendium of Children's Diseases, Am. ed., 201.
[2] Histoire Gén. et Partic. des Anomalies, etc. Paris, 1832–36.

ciples of the bi-nominal nomenclature of Linnæus. This classification is yet in use among French writers. As modified by A. Förster,[1] it may be said to serve the purpose of later systematists. For convenience in reference the system of Förster is herewith appended.

A CLASSIFICATION OF MALFORMATIONS ACCORDING TO FÖRSTER.

I. Monsters per excessum.
  1. Monsters with supernumerary formations.
    A. Double Monsters.
      a. Terata katadidyma.
        Diprosopus (Fig. 197).
        Dicephalus: D. dibrachius (Fig. 198); D. tribrachius; D. tribrachius tripus (Fig. 199); D. tetrabrachius (Fig. 200); D. tetrabrachius tripus.
        Ischopagus. I. tetrapus (Fig. 201).
        Pygopagus (Fig. 202).
      b. Terata. T. anadidyma.
        Dipygus: D. tripus (Fig. 203); D. tetrabrachium (Deradelphe, St. H.).
        Syncephalus. (Cephalothoracopagus, Iniope[2] St. H. Janiceps), (Fig. 204).
        Craniopagus (Fig. 205).
      c. Terata anakatadidyma.
        Prosopthoracopagus (Hemipage, St. H., Epignathus Prosopopagus) (Fig. 206).
        Thoracopagus (Sternopagus, Synthorax): T. tribrachius (Fig. 207); T. xiphopagus; T. tripus; T. parasiticus (Fig. 208).
        Rhachipagus.
    B. Three-faced Monsters. (Tricephalus.)
    C. Supernumerary.
      Formation of single limbs and organs.
      of all or part of limbs.
      of fingers and toes.
      of some bones and muscles.
      of viscera.
  2. Monsters with excessive formation.
    Excessive size of entire body.
    Precocious developments.
    Excessive size of limbs and certain organs.
II. Monsters by defects.
  1. Incomplete formation of the entire or part of body.
    A. Acardiaci.
      Amorphus (Anideus, Mylacephalus, St. H.) (Fig. 209[1]).
      Acormus (Fig. 210[2]).
      Acephalus (Fig. 211).
    B. Dwarfs (Nanosomia, Microsomia).
  2. Incomplete formation of special parts of the body.
    A. Incomplete formation of limbs.
      a. Of all extremities: Amelus (Fig. 212); Peromelus (Fig. 213); Phocomelus (Fig. 214); Micromelus.
      b. Of superior extremities: Abrachius; Perobrachius; Microbrachius; Monobrachius.
      c. Of inferior extremities: Sympus (Sympodia Sirenmonster); S. apus (Sirénoméle. I. St. H.) (Fig. 215); S. monopus (Uroméle. I. St. H.) (Fig. 216); S. dipus (Syméle. I. St. H.) (Fig. 217); Apus (Fig. 218); Monopus (Fig. 219); Peropus (Micropus).
      Achirus (Perochirus) (Figs. 220, 221).
      d. Of hand and feet: A. dactylus (Perodactylus, Microdactylus); Syndactylus (Fig. 222).
      Lunatio congenita.
      e. Lower limb and foot: L. fem. congen. (Dysarthrosis ilio-femoris); L. genu congen.; L. pedes congen.; Pes varus; Pes valgus; Pes equin.; Talipes.
      f. Upper limb and hand: L. humeri congenita; L. radii congenita; L. manus congenita.

[1] Misbildungen. [2] Synote St. H.

[1] The description of this fig., p. 753, is as follows :—
a, *b*, umbilical artery and vein; *c*, sac filled with a whey-like fluid; *d*, *e*, solid processes; *f*, skin mass; *g*, a fold of amnion; *h*, a *cul-de-sac* resembling mesentery.

[2] The description of this figure, p. 753, is as follows :—
a, spongy mass in the position of the brain; *b*, the left palpebral fissure; *c*, the right palpebral fissure; *d*, the nose; *e*, the mouth; *f*, the right ear; *g*, *h*, occipital sac; *i*, an undetermined mass; *h*, the umbilical cord.

Fig. 197.



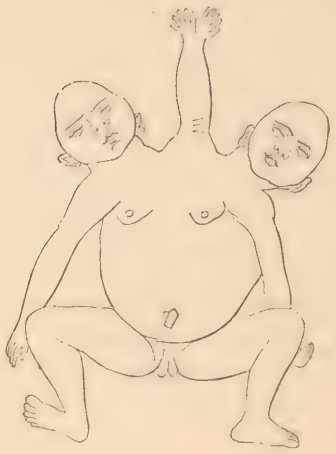
Diprosopus triophthalmus.

Fig. 198.



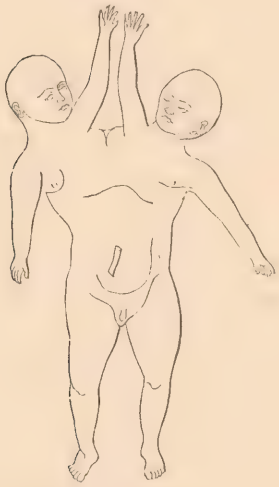
Dicephalus dibrachius.

Fig. 199.



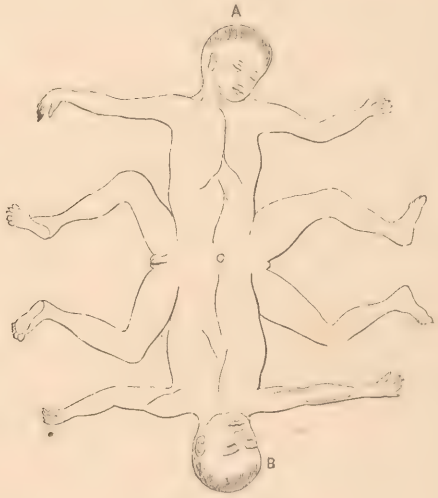
Dicephalus tribrachius.

Fig. 200.



Dicephalus tetrabrachius.

Fig. 201.



Ischiopagus tetrapus.

Fig. 202.



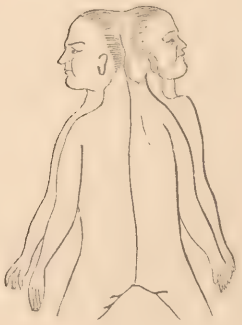
Pygopagus.

Fig. 203.



Dipygus tripus.

Fig. 204.



Syncephalus.

Fig. 205.



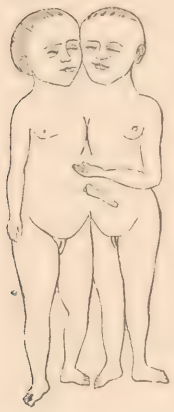
Kraniopagus parasiticus.

Fig. 206.



Prosopothoracopagus.

Fig. 207.



Thoracopagus tribrachius.

Fig. 208.



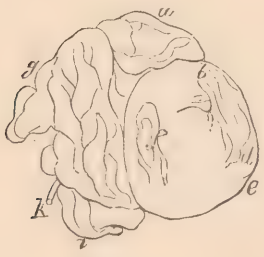
Thoracopagus parasiticus.

Fig. 209.



Amorphus.

Fig. 210.



Acormus.

Fig. 211.



Acephalus.

Fig. 212.



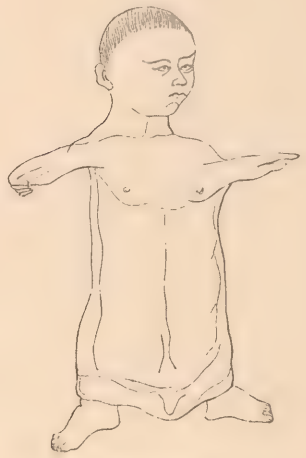
Amelus.

Fig. 213.



Peromelus.

Fig. 214.



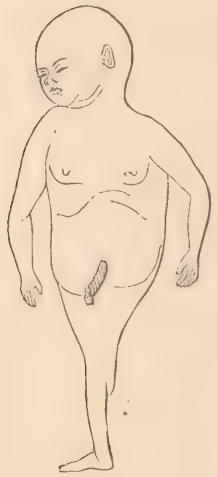
Phocomelus.

Fig. 215.



Sympus apus.

Fig. 216.



Sympus monopus.

Fig. 217.



Sympus dipus.

Fig. 218.



Apus.

Fig. 219.



Monopus.

Fig. 220.



Perochirus.

Fig. 221.



Perochirus.

Fig. 222.



Syndactylus.

Fig. 223.



Anencephalus.

Fig. 224.



Hemicrania.

Fig. 225.



Hydrencephalocele anterior.

Fig. 226.



Hydrorrhachis cervicalis.

Fig. 227.



Agnathus.

B. Incomplete formation of skull and vertebral column.
- Cyclopia (Monopsia, Monophthalmia).
- Hydrops canalis medullaris.
- Anencephalus (Amyelie) (Fig. 223).
- Hemicrania (Fig. 224).
- Cranioschisis (Rhachischisis).
- Hydrencephalocele (Hydromecele) (Fig. 225).
- Hydrorhachis (Hydrocephalus) (Fig. 226).
- Micrencephalis (Cretinisin).
- Partial defects of brain and of the spinal cord.

C. Incomplete formation of the face.
- Agnathus (Fig. 227).
- Schistoprosopus (Aprosopus).
- Cheiloschisis. Gnathoschisis. Palatoschisis.
- Synchelia.
- Microstomia.
- Micrognathia (Atelognathia).
- Achelia (Microchelia, Bachychelia).
- Aglosia.
- Microglossia.
- Schistoglossia.

D. Incomplete formation of the neck.
- Fistula colli congenita.

E. Defects and atresia of the chest.
- Defects of the thorax.
- — of the mamma.
- — of the lung and the heart.
- Defects and atresia of the œsophagus, the larynx, the trachea.

F. Incomplete formation of the abdomen.
- Arrest of development of the abdominal wall, etc.
- Incomplete development of the abdominal wall.
- Umbilical hernia.
- Inversion of bladder, ectrophy of bladder.
- Forms of cloacal retention.
  - With the abdominal wall and the bladder split.
  - With the bladder alone split.
  - The bladder entire.
    - Complex forms.
    - Simple forms.

While such a classification of defects may serve for purposes of identification and for the arrangement of cabinets, it serves imperfectly its purpose as a guide to their separate study. The ensuing pages will treat of the manner by which specimens of congenital or other defect can be most advantageously undertaken by the student. Every specimen should, when it is practicable, be carefully dissected, and from a single specimen of monstrosity several instructive anatomical preparations may be obtained.

The arrangement of the subject-matter in this portion of the book will be as follows:—

(A) *The parts of the embryo* (*Teratological Regions*) *in which defects occur.*

The teratological regions are six in number.

(1) The Blastodermic Membrane and its three Layers.

(2) The Region of the central Nervous System and of the Vertebral Column.

(3) The Region of the Alimentary Tract and of the Body Wall.

(4) The Region of the Omphalo-Mesenteric Tract and of the Allantois and Placenta.

(5) The Region of the Genito-urinary Apparatus.

(6) The Region of the Heart and the Visceral Arches.

(B) *The forces* (*Laws of Morphology*) *which underlie congenital malformation.*

(1) Gemmation.

(2) Parts which are arranged in Serial Order.

(3) In illustration of the law of Reversion.

(4) In illustration of the law of Symmetry.

(A) THE PARTS OF THE EMBRYO (TERATOLOGICAL REGIONS) IN WHICH DEFECTS OCCUR.

(1) The Blastodermic Membrane and its three Layers.—The ovum possesses a thick transparent wall called the vitelline membrane or *zona pellucida*. Within this and forming the great portion of its contents is a semi homogeneous substance termed the yolk or *vitellus*. Lodged in the vitellus, but out of its centre, is a rounded nucleus-like substance termed the *germinal vesicle*; and within this again a nucleolus-like particle, the *germinal spot*. Soon after the escape of the egg from the ovary and before impregnation, the germinal vesicle and germinal spot disappear; and at the same time on the periphery of the egg a rounded projection is formed opposite the locality at which the nucleus and nucleolar elements of the egg were situated. This projection, which is indifferently termed the *polar globule* or

polar vesicle, in time becomes constricted at its base, is cut loose from the egg, and is lost.

Coincidently with this occurrence at the point where the germinal spot and germinal vesicle have disappeared, a structureless spot appears with lines of the granules of the vitellus arranged as radii toward it, the whole assuming a star-like form which has received the name of the *arch-amphiaster*, and which at the same time forms the *female pro-nucleus*, the latter being the name given to that portion of the egg which is alone susceptible of receiving the male impression.

The egg is now ready for the spermatic filament. This essential factor to the subsequent changes effects its entrance into the egg at a point opposite the position of the female pro-nucleus, and so modifies the disposition of the granules about a structureless centre as to form another arrangement, which, closely resembling the female pro-nucleus, has received the name of the *male pro-nucleus*. The pro-nuclei advance toward each other and merge at about the centre of the egg. Conception has now occurred.

The changes following conception are, first, segmentation; and, second, the formation of the blastodermic membrane.

Segmentation is the act of division of the vitellus into successively smaller and smaller masses. This begins by the vitellus forming two equal hemispheres, each hemisphere dividing in its turn, and each of these four parts again dividing. The process is continued until the entire vitellus is converted into a great number of minute spheres, which are called collectively the *mulberry mass*. The following is thought to be the manner after which the segmentation is accomplished.

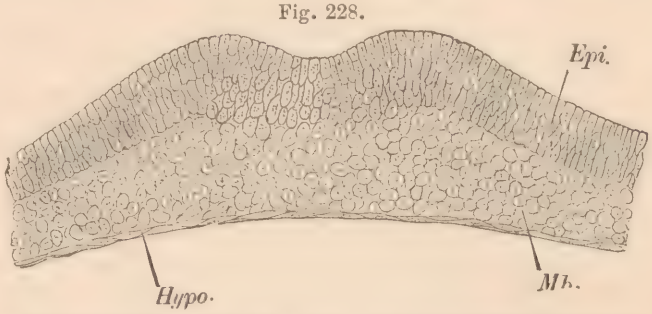
The conjoined pro-nuclei form a central star-like figure which tends soon to be bi-polar, each pole recalling the form of the amphiaster, and by traction on the intermediate substance causing it to assume a ribbed or lined appearance.

The granules of the vitellus range themselves about each of the polar amphiasters until there appears a nearly structureless space between the now localized hemispheres, along which fission occurs, and the intermediate substance between the amphiasters is severed in the centre. No sooner is the form of each hemisphere determined than the same process is repeated, the bi-polar disposition always occurring in the main axis of the mass. As a result of this method of division the essential quality of the impregnated egg is evenly distributed in such manner that when the process ceases each of the spherules of the mulberry mass contains a portion of both male and female elements.

After complete segmentation the upper or dorsal portion of the egg is known as the *germinative area*. It is translucent, and in time is occupied by a sheet or layer of closely aggregated granules, which is called the blastodermic membrane.

The *blastodermic membrane* shortly undergoes horizontal cleavage into three layers (Fig. 228): the

Fig. 228.



Transverse section of blastoderm of fowl's egg at the situation of the primitive trace and primitive furrow—epiblast, mesoblast, hypoblast.

upper or epi-blast, the middle or meso-blast, and the lower or hypo-blast. Each of these develops certain organs of the body, which may be grouped thus:—

"The *epiblast* forms primarily two important parts of the body, viz., the central nervous system and the epidermis.

"It is from the involuted epiblast of the neural tube that the whole of the gray matter of the brain and spinal cord appears to be developed, the simple columnar cells of the epiblast being apparently directly transformed into the characteristic caudate nerve-cells. It is probable that the white matter of the brain and spinal cord is derived from the mesoblast alone. The epithelium (ciliated in the young animal) lining the canalis centralis of the spinal cord, together with that lining the ventricles of the brain, all which cavities and canals are derivatives of the primary neural canal, is the undifferentiated remnant of the primitive epiblast. From the epiblast are formed all such tegumentary organs or parts of organs as are epidermic in nature.

"In addition to these, the epiblast plays an important part in the formation of the organs of special sense. According to their mode of formation, these organs may be arranged into two divisions. In the first come the cases where the sensory expansion of the organ of special sense is derived from the involuted epiblast of the medullary canal. To this class belongs the retina, including the epithelial pigment

of the choroid, which is formed from the original optic vesicle budded out from the fore-brain. To the second class belong the epithelial expansions of the membranous labyrinth of the ear, and the cavity of the nose, which are formed by involution from the superficial epiblast covering the external surface of the embryo. These accordingly have no primary connection with the brain. It may be supposed that the 'taste bulbs' and the nervous cells which have lately been described as present in the epidermis are also structures formed from the epiblast. In addition to these the crystalline lens is formed of involuted epiblast and the cavity of the mouth lined by it.

"From the *hypoblast* are derived the epithelium of the digestive canal, the epithelium of the trachea, bronchial tubes, and air-cells, the cylindrical epithelium of the ducts of the liver, pancreas, and other glands of the alimentary canal, as well as the hepatic cells constituting the parenchyma of the liver, developed as we have seen from the solid hypoblast cylinders given off around the primary hepatic diverticula.

"Homologous probably with the hepatic cells, and equally of hypoblastic origin, are the spheroidal 'secreting cells' of the pancreas and other glands. The epithelium of the salivary glands, though these so exactly resemble the pancreas, is of epiblastic origin, inasmuch as the cavity of the mouth is lined by epiblast. The hypoblast also lines the allantois.

"From the *mesoblast* are formed all the remaining parts of the body. The muscles, the bones, the connective tissue, and the vessels, both arteries, veins, capillaries, and lymphatics with their appropriate epithelium, are entirely formed from the mesoblast. All the nerves of the body, both the cranial nerves (the so-called optic and olfactory nerves alone excepted), the spinal nerves, and the sympathetic system, are formed from the mesoblast. The nerve-cells of the sympathetic ganglia as well as those of the ganglia on the posterior roots of the spinal nerves are of mesoblastic origin, and thus apparently are in striking contrast with the nerve-cells in the brain and spinal cord. The fibres constituting the white matter of both brain and spinal cord are probably derived from the mesoblast.

"The generative and urinary organs are entirely derived from the mesoblast. It is worthy of notice that their epithelium, though resembling so closely the hypoblastic epithelium of the alimentary canal, is distinctly mesoblastic.

"From the mesoblast lastly are derived all the muscular, connective, and nervous and vascular elements, as well of the alimentary canal and its appendages as of the skin and the tegumentary organs. Just as it is only the epidermic moiety of the latter which is derived from the epiblast, so it is only the epithelium of the former which comes from the hypoblast."[1]

Remarks.—In the human subject any gross defect of the arrangements of the layers of the blastoderm will end in the death of the germ; little or nothing is known beyond this. In the lower animals a few observations have, however, accumulated.

Fol describes examples in the starfish of more than one spermatic filament entering the egg at or about the same time, resulting in irregular and defective unions between the female pro-nucleus and the multiple male pro-nuclei. The starfish possesses a transitional embryonic structure which, from its resemblance to the permanent arrangement of parts in the sponges and related animals, has received the name of the *gastrula*. The gastrula becomes deformed when a number of spermatic filaments effect their entrance into the egg. Individuals so deformed never attain to the succeeding stages of development.

Although nothing similar to the deformed gastrula has been observed in the higher animals, in the absence of other explanation the disturbing influence of an excess of sperm-force may be assumed to operate in all eggs, and it would appear to explain at least one form of monstrosity, viz., that in which two embryos, each having its own umbilical vesicle, and from that fact presumed to have its own portion of yolk-food, have been united by the crowns of the heads. (See Fig. 205.) It is here necessary to believe that two head-folds have appeared, not side by side, but with their convex surfaces apposed, each head-fold remaining intact. The ventral aspects of the two embryos in such a monster are not upon the same plane. Inasmuch as the ventral aspect is always on the under surface of the embryo it is likely that one of the embryos has undergone rotation from its original position. In some instances rotation to the extent of one-half of a circle has occurred, so that the face of one individual is upon the same plane as the occiput of the other. In other examples a quarter revolution has taken place, and the face of one embryo is presented to the plane of the profile of the other. Such malformations would not be apt to occur in creatures not possessing placental attachments; since, if the em-

[1] Quoted from "The Elements of Embryology," by M. Foster and F. M. Balfour, 197.

bryos were entirely dependent upon the yolk-sac for nourishment, they would be unlikely to present the ventral surface away from the underlying vitellus.

All errors of a gross character doubtless are announced at an early period in the history of the embryo, and the features attending the primal cleavage into the epiblast and hypoblast are probably modified at this time if defects of the central nervous system or of the genito-urinary apparatus are profoundly impressed. The errors of mesoblastic origin may prove to be of later origin; and owing to the more plastic character of this layer as compared to the more fixed character of the remaining layers of the blastoderm it is probable that even some acquired defects may be mesoblastic in nature. It would be a useful tentative position for the pathologist to accustom himself to view many forms of morbid growth, particularly the myxomata and sarcomata, as expression of mesoblastic development, occurring out of place and order.

The influence exerted in the formation of all structures from a well-defined layer of the blastodermic membrane probably persists throughout life, and it is a valuable hypothesis to assume that all such structures are apt to be associated in constitutional phases of diseased action. The subjoined illustrations are presented of this subject, which promise to be of interest in clinical and pathological studies. In congenital syphilis the following localities are often the seat of diseased action: The oral angle, the enamel caps, the nail-bed and nail, the retina, and the cornea. All of these structures are entirely of epiblastic origin excepting the cornea, which receives some mesoblastic elements in addition. Tumors which exhibit metastatic tendencies, that is, those which involve structures, secondarily by transfer of cells and tissue, fragments by the bloodvessels, are of hypoblastic origin. Among skin diseases, ichthyosis and psoriasis are included by E. Lesser[1] among the anomalies of the cuticle, and are of epiblastic origin.

The anus is lined with an involuted portion of epiblast from the perineum, while the rectum, excepting the portion near the anus, and the remaining portion of the alimentary canal, are of hypoblastic origin. It is interesting to note that the affections of the anus and rectum for an inch or so above the anus are in the main distinct from those of the remaining portions of the rectum and the alimentary canal. Metastatic conditions are unknown at the anus and the lower sixth of the rectum.—The mouth is lined with an involution of epiblast, from a diverticulum of which the anterior lobe of the pituitary body is formed, while the pharynx, as stated by Balfour, is lined by a membrane of hypoblastic origin. It is observable that the separation of the two is sharply outlined at the oro-pharyngeal aperture. The oral region and the pharynx are thus embryologically distinct. The structural diseases of the mouth correlate with the cuticle, as, for example, the presence of hypertrophy of the gum with hirsute growths of skin; and some of the pharyngeal diseases, at least, with the deep-seated visceral chambers.—In connection with this phase of the subject may be mentioned the communication of the lymph-tracts of the roof of the pharynx with the lymph-spaces of the base of the brain. Diseases of the roof of the pharynx (conceding the foregoing premises to be well based) should be grouped in common with those of the pituitary body and of the base of the skull. The retention of osseous canals which extend from the pituitary fossa to the under surface of the basilar process may thus be made capable of a practical application;[1] and the presence of hairy growths from the sides of the pharynx, as described by P. S. Abraham,[2] by reason of their affinity with dermoid growths of the pituitary body, becomes of more than exceptional morphological interest.

(2) THE REGION OF THE CENTRAL NERVOUS SYSTEM AND THE VERTEBRAL COLUMN.

On the first day in the development of the cheek the epiblast sends up two ridges or folds upon the upper aspect, and in this way causes the outer surface of the egg to depart from the form of the sphere. These ridges are named the *medullary folds*, and the space between them *medullary groove*. The folds at one end unite to form the head fold, the posterior end of the groove remaining open. Behind the medullary groove, but not continuous with it, is a delicate linear depression, which is the so-called *primitive groove* or *primitive trace* (Fig. 228). It disappears in a little while without furnishing any clue to its significance. Foster and Balfour[3] incline to the opinion that it is a rudiment of an early structure of some unknown ancestral form of life.

About the head fold and the medullary folds are developed the *proto-vertebræ* (under which name are

[1] Ziemssen's Handbuch, Hautkrankheiten, 470.

[1] See Axel Key and Retzius (Studien in der Anat. des Nervensystems und des Bindegewebes, Stockholm, 1875, 217–220, Taf. xxxvii.–xxxix.); also Waldeyer (Archiv f. microscop. Anat., xvii. 1880, 366).

[2] Journ. of Anat. and Phys., xv. 1881, 244.

[3] Elements of Embryology, Part I. 50.

included the rudimentary and transitional hard parts arranged in the long axis of the embryo, under the position of the future vertebral column) (Fig. 229), the spine, and its contents.

Fig. 229.



Human embryo about one month old, showing the growth of the frontal process downward, and that of the superior and inferior maxillary processes from the side. The proto-vertebræ are distinctly shown.

Remarks.—Defects of the cavity of the central nervous system are of two kinds: First, the defects arising within the nerve-matter itself, and second, those arising from the imperfect development of the walls of the skull and of the vertebral canal. Under the operations of the law that a deeply seated structure influences the development of the superficial parts whose function it is to cover in, and protect such structure (see p. 749), it will be seen, when both the deeply seated and inclosing structure arise from the same layer in the blastoderm—the epiblast—that the correlation between the rate of development of the two must be more than usually exact. In spina bifida, for example, in which condition, owing to the distension exerted by the fluids within the cerebral canal of the cord or its membranes, the medullary folds have failed to unite, the spinal cord itself is often defective. Spina bifida is more common at the lower portion of the vertebral column than elsewhere, but may involve the occiput.—In like manner the defects of brain development correlate with corresponding defects in the vertex of the skull.

In Acrania the brain may be absent, and the skull be without vertex; or a mere rudiment of the brain may be found inclosed in a relatively large dorsal sac. The frontal and occipital portions of the vertex may be absent.

The condition known as *syringomyelus*, in which the central canal of the spinal cord is larger than usual, may be congenital, and relate to an imperfect closure of the medullary groove.[1]

[1] See, in connection with this subject, F. Taylor, Trans. Path. Soc. Lond., xxix. 1878, 21, and E. Leyden, Virchow's Archiv, lxviii. 1. See also variations of the spinal cord, p. 470.

(3) The Region of the Alimentary Tract and the Body-Wall.

At an early period the margin of the blastodermic membrane becomes thickened mainly by the increase of mesoblastic elements, and is cleft horizontally into two leaves. The inner of the leaves unites with the epiblast to form an inner tube, which constitutes the alimentary canal, its appendages, and the umbilical vesicle: from this circumstance it receives the name of the *splanchnopleure*. The outer of the leaves uniting with the hypoblast constitutes the body-wall of the embryo, particularly that of the thoracico-abdominal chamber, and has received the name of the *somatopleure*.—It will be noted that the striated muscle-fibres of the body-wall are of somatopleure-origin; and that the unstriated muscle-fibres of the abdominal tract are of splanchnopleure-origin.—The space between the splanchnopleure and the somatopleure is called the *pleuroperitoneal space*, and is lined with a serous membrane. This arrangement of parts persists with unimportant modifications in fishes, batrachia, reptiles, and in the majority of birds; but, in some birds and in mammals, the Diaphragm intervenes between the thoracic and peritoneal spaces.

Remarks.—Among the defects of the *somatopleure* may be mentioned the following: The entire *abdominal wall may be absent* and the intestines be exposed or protected by the parietal peritoneum only. The urachus may persist, and the abdominal wall from the navel down to the pubis be imperfect or absent. Herniæ of the liver and intestine frequently occur, especially at the position of the umbilicus, which even in slight degrees of defect of the abdominal wall is liable to be larger and more patulous than is normal, and to aid in maintaining intestinal protrusions.

In the chest the *sternum may be absent*, from which the variety of defect known as *Ectopia cordis* is derived.—The Diaphragm may be absent.—In lateral duplication of parts the thorax is variously deformed.

The presence of diverticuli of the intestine, and the union of a diverticulum with the umbilicus may be accepted as errors of development of the *splanchnopleure* and its ducts. In like manner the general history of the variations in the alimentary canal and its appendages may be referred to the impress made upon the embryo at the time of the appearance of the splanchnopleure.

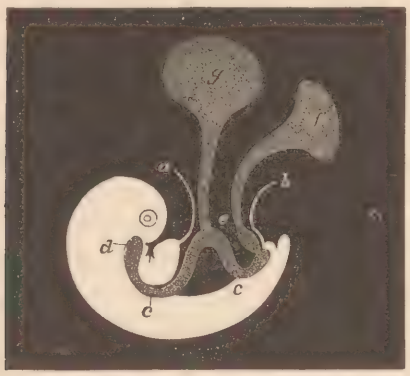
This subject of retained omphalo-mesenteric vessels

and diverticuli as causes of intestinal obstruction has been elaborately elucidated by R. H. Fitz.[1]

(4) THE REGION OF THE OMPHALO-MESENTERIC TRACT, OF THE ALLANTOIS AND THE PLACENTA.

This includes the nutritive, circulatory, and respiratory systems of the embryo. The blastodermic membrane is nourished by the lower layer of hypoblastic cells sending protoplastic processes into the umbilical vesicle. A marginal extension of the hypoblast and the splanchnopleure incloses the vesicle, and the contents are gradually appropriated. The remains of the umbilical (Fig. 230) vesicle are known as the *splanchnic*

Fig. 230.



Formation of the alimentary canal. *a b*, Commencement of the amnion; *c c*, intestines; *d*, pharynx; *e*, urinary bladder; *f*, allantois; *g*, umbilical vesicle.

stalk. When the fœtus secures attachment to the walls of the uterus these remains are held to the under surface of the fœtus by a long thin pedicle.

The umbilical vesicle disappears as development progresses in the pig, the mare, the cetaceans, and the ruminant types, so that no trace of it can be seen in the membranes of the advanced embryo. In the carnivorous animals, including the seals, it forms a well-defined sac in relation to the abdominal sac of the fœtus situated between the allantois and the amnion. In the rabbit the umbilical vesicle reaches the chorion and forms a large sac in contact with a considerable portion of that membrane.[2]

While, however, this process of absorption is going on, a system of vessels is developed within the mesoblast of the embryo which supplants the protoplasm of the hypoblast in the work of carrying up into the embryo the liquefied contents of the umbilical vesicle. This system of vessels has received the name of the *omphalo-mesenteric system*. In time yet a third set of vessels is required (since the umbilical vesicle in mammalia at least is of temporary use only, and is not adapted for respiratory purposes), which is developed through the *allantois*, an account of which structure necessitates some understanding of the membranes of the egg, for it is through the medium of the membranes that the allantois proves so efficient as an appendage to the circulatory and the respiratory systems.

To the outer side of the medullary fold from the upper surface of the blastoderm, a pair of folds arise containing epiblastic and mesoblastic elements which from their future use in forming the amnion are called the *amnionic folds*. Each of the amnionic folds approaches the median line over the position of the medullary folds, and by fusing with the corresponding fold on the opposite side of the median groove inclose the embryo in a special chamber—the amniotic chamber—which is eventually lined with epiblastic pavement epithelium cells, and secretes the amniotic liquid (liquor amnii) (Fig. 231). The connection of

Fig. 231.



Human embryo and its membranes in the early period of gestation, showing the formation of the umbilical cord.

the amnion with the nutritive system of the fœtus is not included in this plan. To account for such inclusion it should be remembered that before the amniotic folds meet a lateral growth of each fold is also announced which gradually underlies the zona pellucida in its entire extent, and constitutes the *subzonal* membrane (serous envelope) of the ovum (see Fig. 237).

The wall of the impregnated egg is called the *chorion*. By the time development has so far advanced as to present an amniotic chamber, the chorion is everywhere covered with a great number of villus-like processes, and is said to be *shaggy*.

[1] Am. Journ. of Med. Sci., N.S. clxxv. 1884, 30, literature; see, also, variations of superior mesenteric artery and the omphalo-mesenteric artery, p. 395, and of the general consideration of veins, p. 411 of this book.

[2] Introduction to Human Anatomy, W. Turner, 865.

In order to show the significance of the shaggy chorion it is necessary to study some of the later changes in the interior of the egg. After the amnion is formed, and the splanchnopleure is determined, a small bud-like process is projected from the hypoblast, and appears upon the under surface of the embryo between the umbilical vesicle and the sub-zonal layer. This is the *allantois*.

Fig. 232.



Diagram of the embryo and its vessels, showing the circulation of the umbilical vesicle; and also that of the allantois, beginning to be formed.

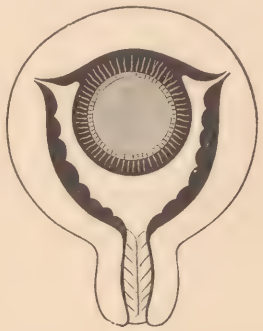
The allantois grows downward and outward increasing in size as the umbilical vesicle diminishes, and tends to approach the sub-zonal layer, and, expanding as it does so, unites by a relatively broad surface of contact with the layer last named and through it with the shaggy chorion, while its point of origin remains narrowed and stem-like. The abdominal vessels pass freely into the allantois, and by the time its development is completed it is very vascular.

The allantois is thus a projection of mesoblast containing a lining membrane of hypoblast. Its walls define a space which is known as the *allantoic space*, and is filled with fluid—the *allantoic liquid*.

The pedicle of the allantois is at a later period continuous through the urachus with the urinary bladder, and, at a time when the abdominal viscera are developed, the pedicle of the allantois becomes the umbilical cord.

Uterine changes incident to pregnancy.—The egg in the time during which the above-named changes have been effected has passed from the Fallopian tube into the uterus, the walls of which are peculiarly prepared for its reception. Instead of being smooth they are now tufty; instead of being firm they are now soft and yielding. The egg is soon arrested by its own villoid processes which catch upon the inequalities of the soft lining membrane of the uterus, and its further descent prevented.—The uterine membrane now embraces the egg, and retires it, as it were, from the general uterine cavity (Fig. 233).

Fig. 233.

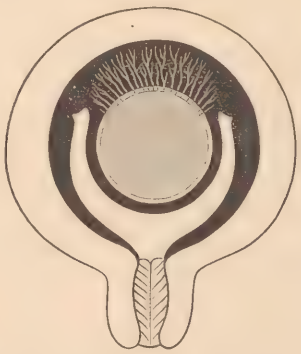


Impregnated uterus, showing the connection between the villosities of the chorion and the decidual membranes.

A few terms which require definition are employed in describing the relations between the uterus and the impregnated egg.

The whole lining membrane of the uterus in its peculiar changed condition due to the influence of an impregnated egg descending the Fallopian tube, is called the *membrana decidua*. That portion of the membrane lining the uterus other than the surface of contact of the egg is called the *membrana decidua vera;* that portion at which the contact takes place between the egg and the uterine wall is called the *membrana decidua seritona;* and that portion inclosing the egg is called the *membrana decidua reflexa* (Fig 234.)

Fig. 234.



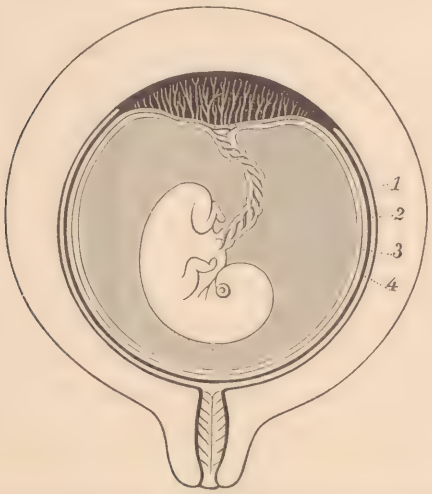
Pregnant uterus, showing the formation of the placenta by the local development of the decidua and the chorion.

The surface of contact of the allantois with the chorion so influences the nutritive processes in the latter membrane that the villi of the shaggy coat at this place effect firmer union with the uterine membrane than elsewhere. Indeed at all points other than the one indicated the villoid processes disappear.

The Placenta is the result of modifications excited

between the retained patch of shaggy chorion and the *membrana decidua seritona* (Fig. 235).

Fig. 235.



Pregnant human uterus and its contents, about the end of the seventh month, showing the relations of the cord, placenta, and membranes. 1, Decidua vera; 2, decidua reflex; 3, chorion; 4, amnion.

The placenta serves as the medium of interchange of nutritive and excreted material during pregnancy. At birth the attachments are loosened; the placenta (fœtal placenta) is severed from the uterine wall (maternal placenta), and comes away as so much useless material. From the moment of its severance the infant requires nourishment through the channels which characterize all forms of extra-uterine existence.

The *structure* of the placenta has been made the subject of special study by many accomplished anatomists since the time of William Hunter, and it yet remains in some particulars a subject of controversy. The following description, abridged from an account[1] by Prof. Turner, is herewith introduced.

The relation of the fœtal and maternal portions of the placenta can be best studied at about the fifth month, when the decidua reflex and villi, connected with the non-placental area of the chorion, have atrophied, and the villi in the placental area have undergone a great increase. Well-marked bars or dissepiments of decidua serotina pass through the thickness of the placenta as far as the chorion, and divide it into lobes or cotyledons. These bands and their subdivisions and separate trabeculæ form the *serotinal membrane*, which, giving rise to still more delicate offshoots, forms a minute intra-placental trabecular arrangement in the interstices of which the villi are lodged. The maternal bloodvessels are now dilated into sinuses, and are also prolonged into the placenta along the cellular structures of the decidua serotina, so that the dilated vessels of the modified uterine mucous membrane are brought into relation with the vascular villi of the fœtal chorion. The placenta when matured presents the appearance of a disc-shaped spongy cake, which measures from seven to nine inches in diameter, and about one inch in thickness; toward its circumference it is somewhat thinner. The inner (chorionic) surface exhibits ramifications of the umbilical vessels, and is closely covered on its fœtal side by the amnion; from its placental (outer, serotinal) side multitudes of arborescent vasculi villi arise (Fig. 236).

Fig. 236.



Diagram of the embryo and its vessels, showing the second or placental circulation. The intestine has become further developed, and the mesenteric arteries have enlarged, while the umbilical vesicle and its vascular branches are reduced in size. The large umbilical arteries are seen passing out to the placenta.

The arrangement of the bloodvessels in the decidua serotina is as follows: The peculiar tortuous arteries of the decidua—the *curling arteries*—are continuous with the convoluted uterine arteries. They pierce the decidua serotina, and open upon the placental surface. The veins of the decidua serotina are directly continuous with the mouths of the curling arteries. These veins — the utero-placental veins — form an extensive series of large *cavernous spaces* (placental sinuses, lacunæ, placental cells, inter-villal spaces, placental bag or sac) which freely communicate one with another, not only in a single lobe, but in adjacent lobes through imperfections in

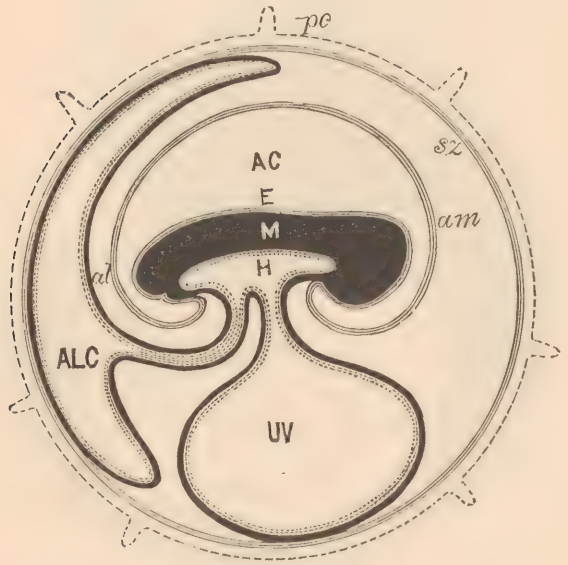
[1] Manual of Anatomy, 874.

the dissepiments. Each cavernous space, as it forms the boundaries of the depressions for a choroidal villus, is lined with a single layer of oval epithelial cells; this acts as a secreting surface, and separates and prepares a secretion from the maternal blood which is absorbed by the vessels of the chorionic villi, and applied to the nutrition of the fœtus.

The placenta is a compound organ, and consists of two series of structures, the one belonging to the fœtus, the *fœtal placenta;* the other to the mother, the *maternal placenta.* The fœtal placenta is formed of the chorion, amnion, allantois, and umbilical vessels.

The *chorion* (primitive chorion, zona pellucida) is the outmost membrane of the egg.

Fig. 237.



A diagrammatic representation of the fœtal membranes. E, Epiblast; M, mesoblast; H, hypoblast; U V, umbilical vesicle; *a l*, allantois (the allantois lies to the left of the letters); *a m*, amnion (the amnion lies to the left of the letters); A C, the amniotic chamber; A L C, the allantoic chamber; *s z*, the subzonal membrane; *p c*, the primitive chorion with villi.

Remarks.—The effects of inflammatory adhesions between the integument and the amnion have been noted on p. 749.—The *decidua vera* and *decidua cerolina*, together with inclosed embryo, may be arrested in development, and constitute the so-called placental male, which in time is expelled from the cavity of the uterus.—The subject of ectrophy of the bladder (see p. 765) involves the pedicle of the allantois, and has close relations to the bloodvessel system of the embryo.

THE REGION OF THE GENITO-URINARY APPARATUS.

The Genito-Urinary tract embraces the organs occupying a position between the peritoneal sac and the vertebral column, and those parts of the nutritive system by means of which the allantois assists in the formation of the urinary bladder.

The teratological region embraced by this apparatus extends along the entire length of the retro-peritoneal space of the adult, and in addition includes the ureter, the bladder, the internal and external organs of generation, as well as the rectum, in its middle and lower portions, and the anus. This extensive tract possesses in common the following embryonic features:—

The Wolffian Body.
The Kidney.
The Ovary.
The Testis.
The External Organs of Generation.
The Bladder and Urachus.
The Prostate Gland and Duct of Gartner.

The Wolffian Bodies.—The genito-urinary apparatus, unlike other anatomical systems, possesses an embryonal structure, in many respects unlike the one permanently assumed. A single structure, termed the Wolffian body, lies in the retro-peritoneal space in the position of the future kidney, and, indeed, performs the work of that gland; at the same time it holds within itself the groove from which both the male and the female genito-urinary organs are derived.

According to the researches of Semper and Balfour, the primordial organ, which arises from the *intermediate cell-mass of the mesoblast*, is composed of three distinct portions, the anterior (pronephros), the middle (mesonephros), and the posterior (metanephros). Of these, the middle portion alone forms the Wolffian body, while the posterior becomes the future kidney; the anterior portion is of obscure function and destiny in the higher animals, and need not here be regarded.

The Wolffian bodies are two elongated tubular masses of a reddish color, found lying in the retro-peritoneal space. The tubuli are arranged transversely from within outward, and empty into a *duct* (Wolffian duct), which runs vertically downward along the outer side of the body to the primitive cloaca. Towards the initial ends of the tubuli, at the lower portion of the Wolffian body, a number of minute structures are seen, which resemble in form and function the Malpighian corpuscles of the kidney.

After an activity ranging from the sixth to the seventh week the Wolffian bodies atrophy, in time disappear, and the subsequent work of excretion during fœtal life falls upon the kidneys.

A few insignificant structures in adult life are identified with portions of the Wolffian body. In the male the organ of Giraldès, the hydatid of Morgagni, and the vas aberrans have this significance, and, in the female, portions of tubuli persist, constituting the parovarium, which lies in the broad ligament near the uterus, and the so-called grains of Folin, which lie near the uterus.

In the sow, some of the ruminant and quadrumanous types, the lower portion of the organ, constituting the duct of Gærtner, also persists. This rudiment is generally described as absent in the human female, but C. Rieder[1] has detected its presence as often as in one out of every three dissections. In one-fifth of these instances it is found as a small tube, extending either parallel to the upper portion of the vagina, or embraced in the muscle-fibres of the cervix uteri, and is lined with cylindrical epithelium. The author thinks it probable that some forms of vaginal cyst take their origin in this rudiment.

In the course of development of the ovary and the testis and the passages with which they are in association, the intermediate mass yields the following structures.

In the development of the testis the parenchyma arises from the stratum beneath the germ epithelium, and exhibits as early as the seventh or eighth week the characteristic tubuli, which are lined with cells (seminal cells) held to be homologous with the germ-epithelium of the ovary. The proper Wolffian duct constitutes the vas deferens and the ejaculatory duct. The vesicula seminalis is formed as an outgrowth from the lower part of the duct. From a specimen of abnormal development described by Turner, in which the globus major was alone absent in the excretory apparatus, it was inferred that this portion of the duct has a distinct development, and probably arises from a separate portion of the intermediate mass which, according to Cleland and Banks, remains distinct from the Wolffian body, and evolves the vasa efferentia, the arcus vasculosa, and the globus major.

The ovary is a differentiation of the median portion of the Wolffian body. It consists of two portions, a stroma and an investing epithelium. The epithelium receives the special name of the *germ-epithelium* of Waldeyer. The ova, which appear at an early period of development, arise from the germ-epithelium, but as they become differentiated are depressed beneath the germ-layer and received in special sacs, (ovi-sacs, Graafian follicles), which arise within the ovarian stroma. The ovary, unlike the testis, is not continuous with its duct; but lies in the peritoneal chambers and in the neighborhood of the initial end of the Fallopian tubes, the fimbriated extremity of which is homologous again with the hydatid of Morgagni. The Fallopian tubes, the uterus, and the vagina constitute special differentiated chambers or sacculations along the course of a single tube which is held to be homologous with the Müllerian duct which lies adjacent, and to the median side of the Wolffian body.

In both sexes the Müllerian ducts and the Wolffian duct are inclosed at their lower portion in a common investing mass which has received the name of the *genital cord* (uro-genital cord). The ducts of Müller coalesce in a portion of their course, but subsequently become distinct. In the female this coalesced portion represents the body of the uterus and the vagina. In the male the Müllerian ducts disappear excepting the vestigial structures which persist in the *hydatid of Morgagni*, and in the terminal portion of the coalesced ducts where they join the urethra is the prostate gland, which has received the name of the *uterus masculinus* (pouch of Weber, vesicula prostatica).

Two interesting cases of union of the ureter and vesiculæ seminales are reported by C. E. E. Hoffmann.[1] The article contains literature of the entire subject of uretral malformation.

The Urinary Bladder and Urachus. The bladder is a pouch developed from the allantois as it projects from the trunk. It is, therefore, of necessity continuous with the stem of the allantois upward and through the navel at the time of the formation of the placenta. Much later, after the elements of the allantois are no longer recognized in the umbilical cord, the connection between the urinary bladder and the navel persists in the form of an open tract termed the urachus (see Bladder, p. 704). The bladder opens in both males and females by the urethra into the uro-genital sinus. The urachus closes after birth, but the bladder retains the elongated form due to the origin of the bladder during childhood.

In *ectrophy of the urinary bladder* the abdominal wall is fissured from the umbilicus to the pubis. The hypogastric region is much smaller than is normal, since the umbilicus is carried to a point near the pubis. The urachus is absent. The only portion of the bladder which has developed is the lower portion

[1] Virchow's Archiv, 1884, xcvi., 100 (fig.).

[1] Archiv d. Heilkunde, xiii. 522, Taf. vii.

of the posterior wall and the *bas fond*. The mucous membrane of the viscus projects at the fissure as a convex swelling, and bears the papillæ of the ureters, from which the urine intermittently trinkles. The symphysis pubis is not completely closed. In males the testicles are either retarded in their descent, or, if they lie within the scrotum, congenital scrotal hernia coexists; the penis is rudimentary. In females the urethra and clitoris are absent, and the vestibule is either narrowed or is closed; the vagina also may be absent. The essential structures of the genito-urinary tract remain as a rule unaffected.

W. Atlee[1] narrates a case in which the question of dilated urachus entered into the question of diagnosis of ovarian tumor.[2]

The External Organs of Generation. Up to the seventh or eighth week the intestinal canal, the ureters, the Müllerian and Wolffian ducts empty into a common chamber, which opens at the inferior pelvic outlet which receives the name of the *cloaca*, an arrangement which persists in reptiles and birds, and the lowest of the mammalia. Subsequently the rectum opens by a separate outlet—the anus—but the genito-urinary apparatus opened in a separate chamber—the *uro-genital* sinus. At this period the perineum exhibits two openings in both sexes, a posterior, which is the *anus*, and an anterior, which is the outlet of the uro-genital sinus.

The external organs of generation are about the same time developed from an indifferent type. Prior to the eighth or ninth week, the penis or clitoris is slightly projected from a circular pad of skin. The penis or clitoris exhibits a cleft beneath which communicates with the aperture of the uro-genital sinus. Beyond the period named the external differences in sex announce themselves. In the female the clitoris is determined by the persistence of the aperture of the uro-genital sinus. The sides of the cleft beneath the organ form the labia minora, which aid in defining the vestibule. The circular pad of integument and fat, shaping itself as the labia majora. In the male, the penis is determined by the closure of the aperture of the uro-genital sinus, and the obliteration of the groove on the under surface of the organ. The pad of skin is converted into the scrotum, which subsequently receives the testis.

Remarks.—Errors of development of the organs of generation may be grouped as follows:—

The Wolffian bodies, instead of forming organs of the same sex, may form the parts comparable to those of a male on one side, and those of a female on the other. This malformation constitutes true or lateral hermaphroditism, and is an exceedingly rare variety of that condition. It has been observed in the hog, the ox, and in man.

The Wolffian bodies are normally metamorphosed to male organs, but the external parts are imperfectly developed. Thus, an empty scrotum exists which resembles in form and position the labia majora; a rudimentary penis is seen which recalls the form of the penis; it is usually imperforate or hypospadic. The uro-genital sinus may persist as a narrowed infolding of the integument suggestive of a vagina. The secondary signs of virility, such as the beard, and the hair on the hypogastric region, are absent. The voice is not sonorous, nor is attraction to the opposite sex, as a rule, acknowledged. Should the uro-genital sinus be capacious, however, the person may pass for a female, and submit to intercourse as such. Dissection of the body reveals small and imperfectly descended testicles.

The Wolffian bodies may be normally metamorphosed to female organs, while the external parts are imperfectly developed. In such aberrant forms the clitoris is larger than in the normally developed female, the vagina may be absent or small, and retain the appearance of a narrowed uro-genital sinus. When examined with care a rudimentary uterus may be detected. The superficial phenomena of menstruation are often present. A sparse beard may exist, the voice is harsh, the disposition masculine. The individuals frequently pass for men, and may have intercourse as such. Dissection shows normally situated ovaries, but the Fallopian tubes may be rudimentary and closed.

The internal organs of generation may be normal and the penis or clitoris be properly defined, but the uro-genital sinus may persist and include the lower portion of the rectum. Or the sinus may, as is normal, disappear and with it all external orifice of the rectum. The latter malformation is known as *congenital imperforate rectum*.

According to O. Beumer,[1] malformation of the genital organs is frequently associated with absence of one kidney. This is seen to be natural enough when it is remembered that the internal organs of generation arise from the same portion of the embryo as the kidneys. An early impress of malnutrition in

[1] Ovarian Tumors, 50.

[2] For an account of the development of the Kidney in man and the lower animals, see Toldt, Proc. Wien. Acad., 1874, 123.

[1] Virchow's Archiv, lx., 1874, 1; Taf. 1.

the undifferentiated tissue of this region would be apt to influence the entire uro-genital tract.

Kidneys.—For variations of the kidneys, see p. 700.

THE REGION OF THE HEART AND THE VISCERAL ARCHES.

The development of the heart and the visceral arches can be conveniently associated.

"At the extreme end of the embryo, where the blastoderm begins to be folded back, the mesoblast is not cleft, and here consequently there is neither somatopleure nor splanchnopleure; but at a point a very little further back the cleavage begins, and the somatopleure and splanchnopleure diverge from each other. They thus inclose between them a cavity which rapidly increases behind. Both folds are turned round again and then course once more forward over the umbilical vesicle. As they thus return (the somatopleure having meanwhile given off the fold of the amnion) they are united again to form the uncleft blastodermic investment of the umbilical vesicle. It is in this cavity, which from its mode of formation the reader will recognize as a part (and indeed at this epoch it constitutes the greater part) of the general pleuro-peritoneal cavity, that the *heart* is formed.

"It makes its appearance at a point where the splanchnopleure folds turn round to pursue a forward course, and by the end of the first half of the second day has acquired somewhat the form of a flask with a slight bend to the right. At its anterior end a slight swelling marks the future *bulbus arteriosus*, and bulging behind indicates the position of the *auricles*. It is hollow, and its cavity opens below and behind into two vessels called the *omphalo-mesaraic* veins (omphalo-mesenteric) which pass outwards in the folds of the splanchnopleure at nearly right angles to the axis of the embryo. The anterior extremity of the heart is connected with the two aortæ.

"Soon after its formation the heart begins to beat, its pulsations are at first slow and rare, beginning at the venous and passing on to the arterial end. It is of some interest to note that its functional activity commences long before the cells of which it is composed show any distinct differentiation into muscular or nervous elements. To provide channels for the fluid thus pressed by the contractions of the heart, a system of tubes has made its appearance in the mesoblast both of the embryo itself and of the vascular and pellucid areas. In front the single tube of the heart bifurcates into two *primitive aortæ*, which pass from its under to its upper side, the two forming together a sort of incomplete arterial collar imbedded in the mesoblast of the gut. Arrived at the upper side of the beginning of the alimentary canal they turn sharply round, and run separate but parallel to each other backwards towards the tail, in the mesoblast on each side of the notochord immediately under the protovertebræ. About half way to the hinder extremity each gives off at right angles to the axis of the embryo a large branch, the *omphalo-mesenteric*, which, passing outward, is distributed over the pellucid and vascular areas, the main trunk of each aorta passing on with greatly diminished calibre towards the tail, in which it becomes lost."[1]

The aortic bulb yields a number of branches which form in the embryo, the system of the aortic or branchial arches. The study of the variations of these arches has already been considered (p. 348). In this place it is designed to show that they are associated in turn with the structures of the head rather than with the trunk, and that as the heart itself is originally a cephalic structure so the defects of this organ and those of the branchial system of blood-vessels should not only be studied together but should embrace the study of the visceral arches as well.

The Visceral arches (branchial arches) are five pairs of buds which appear as buds from the base of the skull, and which project downward on either side of the oval and pharyngeal spaces to join at the median line of the neck. Each arch carries a branch of the aortic system, and is most intimately associated in the plan of the arrangement of the system of vessels in the fœtus and in some batrachians. In this manner the development of the skull is seen to be in part correlated with the development of the heart and is part of the great vessels.

"It must be borne in mind that, especially in the early stages of development, owing to the very unequal growth of different parts, the relative position of the various structures is continually shifting. This is very well seen in the instance of the heart. At its first appearance, the heart is lodged immediately beneath the extreme front of the alimentary canal so far forward as to underlie that portion of the medullary canal which will form the brain. It is, in fact, at that epoch a part of the head. From that early position it gradually recedes farther and farther backward, until, at the end of the third day, a considerable interval is observed between it and the actual head. In other words, a distinct neck has been formed, in which most important changes take place.

"The neck is distinguished from the trunk in which the heart now lies by the important feature that in it there is no cleavage of the mesoblast into somatopleure and splanchnopleure, and consequently no pleuro-peritoneal cavity. In passing from the exterior into the alimentary canal, the three layers of the blastoderm are successively traversed without any breach of continuity save such as is caused by the cavities of the bloodvessels. In this neck, so constituted, there appear on the third day certain fissures or clefts, the *visceral* or *branchial clefts*. These are real clefts or slits passing right through the walls of the throat, and are placed

[1] Foster and Balfour, l. c., 63.

in series on either side across the axis of the alimentary canal, lying not quite at right angles to that axis and parallel to each other, but converging somewhat to the middle of the throat in front. Viewed from the outside in either fresh or preserved embryos they are not very distinctly seen to be clefts; but when they are seen from within after laying open the throat, their characters as elongated oval slits can easily be recognized.

"Four in number on either side, the most anterior is the first to be formed, the other three following in succession. Their formation takes place from within outwards. The hypoblast and mesoblast are first absorbed along the line of the future cleft, then the epiblast is broken through, and the hypoblast, which is carried outwards as a lining to the slit, forms a junction with the epiblast at the outside of the throat.

"No sooner has a cleft been formed than its upper border (*i. e.*, the border nearer the head) becomes raised into a thick lip or fold, the *visceral* or *branchial fold*. Each cleft has its own fold on its upper border, and in addition the lower border of the fourth or last visceral cleft is raised into a similar fold. There are thus *five* visceral folds to *four* visceral clefts. The last two folds, however, and especially the last, are not nearly so thick and prominent as the other three, the second being the broadest and most conspicuous of all. The first fold meets, or nearly meets its fellow in the middle line in front, but the second falls short of reaching the middle line, and the third, fourth, and fifth do so in an increasing degree. Thus in front views of the neck a triangular space with its apex directed towards the head is observed between the ends of the several folds.

"Into this space the pleuro-peritoneal cavity extends, the somatopleure separating from the splanchnopleure along the ends of the folds; and it is here that the aorta plunges into the mesoblast of the body.

"Of the history of these most important visceral folds and clefts we shall speak in detail hereafter; meanwhile we may say that in the chick and higher vertebrates the first three pairs of folds are those which call for most notice.

"The first fold on either side, increasing rapidly in size and prominence, does not, like the others, remain single, but sends off in the course of the third day a branch or bud-like process from its upper edge. This branch, starting from near the outer beginning of the fold, runs forward and upward, tending to meet the corresponding branch from the fold on the other side, at a point in the middle line nearer the front of the head than the junction of the main folds. The two branches do not quite meet, being separated by a median process, which at the same time grows down from the extreme front of the head, and against which they abut. Between the main folds, which are directed somewhat downward and the branches which slant upward, a somewhat lozenge-shaped space is developed which, as the folds become more and more prominent, grows deeper and deeper. The main folds are the rudiments of the *inferior maxillæ*, the branches those of the *superior maxillæ*, the lozenge-shaped cavity between them is the cavity of the mouth, and the descending process which helps to complete the upper margin of this cavity is called, from the parts which will be formed out of it, the *fronto-nasal process*."[1]

The visceral arches are first the *mandibular* which accommodates an axial rod of cartilage about which is developed the lower jaw; second, the *hyoid* which yields the parts of the hyoid apparatus; third, fourth, and fifth are not separately named, though the first has been called by some writers the *thyro-hyoid*. Their destiny in the history of the development of the neck is obscure.

It has been seen that the head develops about the *head fold* of the medullary ridge. The line of protovertebræ and the special notochord extend as a rod into the base of the skull as far as the anterior end of the basilar portion of the occipital bone. The notochord is formed prior to both cartilage and bone, but appears to suggest a substance related thereto. The rod becomes converted into cartilage yielding distinctive buds which pass forward from the region at which the rod terminates. A median extension, or bud, composed of coalesced *trabeculæ cranii*, enters the region of the face, and forms the nasal septum, the crista galli, and the lateral portions of the ethmoid bone. Prior to this coalescence of the trabeculæ, they inclose a space called the pituitary space, into which the infundibulum and the pituitary gland extend.

The trabeculæ have been supposed by some observers to be comparable to a pair of visceral arches. They are, as has been seen, outgrowths from the cartilaginous investment of the notochord, while the visceral arches are related to the mesoblastic masses about the aortic system of vessels, although carrying axial rods of cartilage later. While thus differing in origin they are alike in the assistance they give to the development of the face and neck. From the trabeculæ are probably developed the inner pterygoid plate, the palatine bone, the lower turbinated bone, and portions of the maxilla.

While the lateral structures, seen in the plates from which the maxillæ and the halves of the mandible arise, are extending toward the median line, the superficial median structures which conform to the position of the olfactory vesicle and the cerebral vesicle become conspicuous. These structures include the nasal pit and the fronto-nasal process (Fig. 229).

"Over each olfactory vesicle the external epiblast which covers them grows inward to form a shallow depression with a thickened border. These depressions are the *nasal pits*.

[1] Foster and Balfour, l. c., 118.

"The two nasal pits on the third day are shallow depressions with thickened borders complete all round. As the pits deepen on the fourth day by the growth upward of their rims, a break is observed in each rim in the form of a groove directed obliquely downward towards the cavity of the mouth."[1]

The fronto-nasal process is on the third day a superficial projection caused by the bulging anterior extremities of the vesicles of the cerebral hemispheres; on the fourth day it becomes more prominent, separates the nasal pits from each other, and aids in forming the inner wall of each.

"Abutting on the outer side of each groove and so helping to form the outer wall of each, lie the ends of the superior maxillary processes of the first visceral arch, which like the fronto-nasal process are increasing in size. By their continued growth, the groove is more and more deepened, and leading as it does from the nasal pit to the cavity of the mouth, may already be recognized as the rudiment of the passage of the posterior nares."[2]

Fig. 238.



Head of human embryo at about the end of the second month.

Fig. 239.



Head of human embryo about the sixth week.

The mouth is seen to be a space intervening between the maxillary and mandibulous plates and is lined with epiblast. It does not connect at first with the alimentary canal.

Remarks.—The brain may be in a rudimentary condition, especially the cerebrum, which may remain smooth without hemispheres, olfactory bulb or basal ganglia. With this condition the ethmoid bone is undeveloped, the fronto-nasal process descends imperfectly if at all, the maxillary plates fail to meet the premaxillæ, and are separated by a median fissure of the upper lip. The eyes approximate, and may even merge into one. This malformation constitutes *cyclops*. The maxillary plate of one side (commonly the left) may fail to unite with the corresponding pre-maxilla to constitute *single harelip*, or both may fail to effect their accustomed union, forming as a result *double harelip*. Either of these may be associated with partial or complete cleft of the hard and the soft palate.

The fronto-nasal process may ascend instead of descending, the maxillary plate may nearly unite by reason of the absence of the premaxillæ, when a genuine harelip results, *i. e.*, a cleft which answers to the space between the maxillary plates in the median line. Or the fronto-nasal process may descend and an opening exist on either side as a result of failure of the maxillary plate to unite with the process in question. The palpebral fissures may be continuous with the mucous membrane intervening between the cheeks and the sides of the external nose.[1]—The nose may be absent on one side of the face alone. This condition, which has received the name of *Arhinencephala unilateralis*, is associated with absence of the cribriform plate of the corresponding side. A pendulous tumor from the region of the internal canthus of the affected side has been described by A. Selenkoff.[2]

The mandibular arches may infrequently fail to unite, and cyst-like spaces indicate the interspaces between the ends of the imperfect parts. Richet[3] and J. Jardine Murray[4] have described *dermal crypts* in the lines of defective growth of the jaws.—The defects of the visceral arches upon the neck are exceedingly rare. They are indicated by the presence of *fistulous tracts* which open upon the surface at one or more points of the neck. It is inferred that such tracts are due to imperfect closure of the third or fourth visceral clefts. Cervical fistulæ may communicate with the trachea and the œsophagus. They have been found both on the right and the left side, and at the median line. J. M. Duncan[5] describes a case of a boy aged sixteen years, in whom a reddish spot less than a pin's head in size was situated above the insertion of the sternal portion of the right Sterno-Cleido-Mastoideus muscle. A small quantity of fluid escaped daily. In infancy, milk trickled from the opening when the child was at the breast. The condition was held by the reporter to be a congenital fistule connecting with the œsophagus.

Since the visceral cleft between the mandibular and the hyoid arches extends upward to the ear, and

[1] Foster and Balfour, l. c. 145. [2] Ibid., l. c. 146.

[1] For additional case and figure, see R. Harley, Trans. Obs. Soc., iv. 213.

[2] Virchow's Archiv, 1884, xcv. 95.

[3] Gaz. Hôpitaux, 1861, 174.

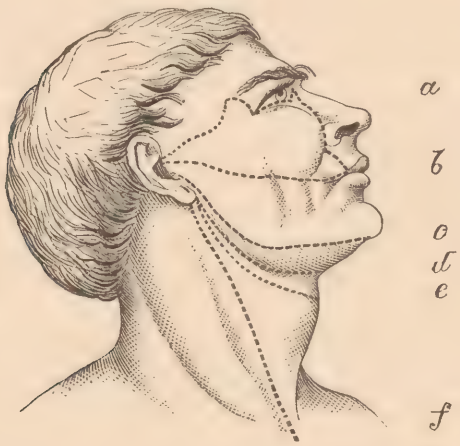
[4] Br. and For. Med.-Chir. Rev., 1860, xxvi. 502.

[5] Edin. Med. Journ., i., 1855, 426.

the Eustachian tube is known to be a survival of the distal portion of this visceral cleft, cervical fistules in the position of the ear are often accompanied with malformation of the ear, particularly of the auricle.[1] In the judgment of C. F. Heusinger,[2] the diverticuli of the œsophagus are of the nature of incomplete cervical fistules.

For the literature of cervical fistulæ and related conditions, see F. M. Ascherson,[3] M. Perls,[4] J. Cusset,[5] Neumann and Baumgarten, and W. W. Wagstaffe.[6]

Fig. 240.



A profile sketch designed to illustrate by dotted lines the position of the branchial fissures. The letters answer to the spaces between the fissures. *a*, the space between parts developed from the *trabeculæ cranii*, and those of the first arch; *b*, the space between the upper and lower masses of the first arch; *c*, the space between the first and the second arch; *d*, the space between the second and the third arch; *e*, the space between the third and the fourth arch; *f*, the space below the third arch.

Fig. 240, from Cusset, will be useful for the location of the lines about which fistulæ and cystic formations may be looked for.

Fig. 241, from Wagstaffe, indicates the position of the last-named condition upon the suture of the facial region.

Not only may the visceral clefts and the spaces between the various parts of the plan of the face fail to unite, but *cysts* may form along the lines of union, and hyperplasia occur at the sutural lines of the bones in this region (Fig. 241). The presence of cysts in the neck should always be studied, as having origin along the lines of the interspaces, and it is probable that most accessions of tissue at sutural lines of bones, as in the

[1] J. Paget, Med.-Chir. Trans., 1878, 39 (literature).

[2] Virchow's Archiv, xxix., 1864, 358, and xxxiii., 1865, 177 (copious literature).

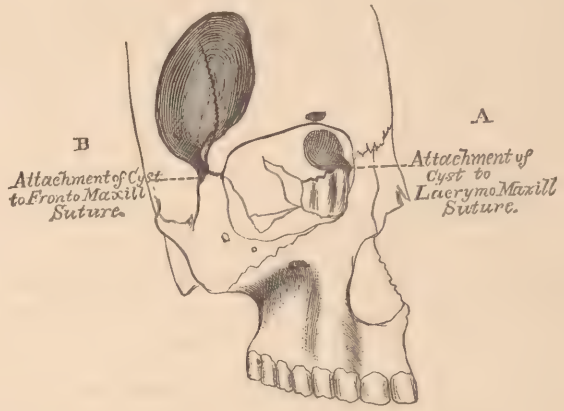
[3] De Fistulis Colli Cong., Berlin, 1832.

[4] Lehrbuch der allgemein. Pathol., 290.

[5] Sur l'appareil branchial des Vertébrés, Paris, 1877.

[6] Tr. Path. Soc. Lond., 1878, 194.

Fig. 241.



A figure of the front of the right facial region, designed to exhibit the points of attachments of congenital cysts of the cranial sutures.

median sutures of the face, notably those of the hard palate, are probably caused by the continuation of lines of growth, after the right and left parts of the plane have joined one to the other. It is in like manner probable that the existence of ivory exostosis at the root of the nose and in the associated parts may have its origin in a similar deep-lying cause.

On the Study of Correlated Parts.—From the facts of the normal development of the head, the face, the heart, ear, great vessels, and visceral arches, it is evident that a lesion in a single organ lodged within the general region embraced by these structures should be studied with reference to the entire set of organs of which it is a part.[1]

A gross lesion in one part may be correlated with "anomalies," or with "variation" in another. Many minute variations escape detection, unless they are carefully sought for, and it is probable, that unusual proportion in parts so remote as the ossicles, the nasal chambers, the hyoid apparatus, the great cervical and upper intra-thoracic vessels may be found to correlate. The author has found congenital defects of speech to be associated with a shortened tongue, with absence of Shrapnell's membrane, with high arched palate, and nasal asymmetry.

It would appear that the ossicles of the ear are connected with the first and second visceral arches in ordinal arrangement with the series of cartilaginous rods within these arches. Thus the malleus is considered by Reichert to be the distal ossification in a series to which the remaining parts of the mandibular arch are

[1] See a case reported by Max Schultze (Virch. Arch., xx., 1860, 378 (fig.)), in which the first and second visceral arches, symmetrical facial failure, and deformity of the incus and stapes of one side, existed in a single specimen.

homologous; and the anvil to be a part of equal value to it, in the hyoidean arch. Other writers assign the stapes also a place in the succeeding arch. Urbantschitsch, however, following Rathke and Valentin, believes that the malleus and incus develop within the same primitive bud or outgrowth, and are related, if with any, only with the mandibular arch.[1] However the question of the homologies of the ossicles may be settled, the claim that in their ranges of variation they correlate with the structures evolved from the visceral arches is in no way invalidated.

(B) THE FORCES (LAWS OF MORPHOLOGY) UNDERLYING CONGENITAL MALFORMATION.

(1) GEMMATION.

By gemmation is meant a process of budding. Originally observed in plant-life, it has been found a constant phenomenon of the coral and coral-like animals,[1] and in the early stages of life of all animals. Buds, or gemmæ, are ordinarily projected from the sides of a trunk or the main body; but they may arise from the interior of an organ by a process of involution. The former variety of gemmation is illustrated in the growth of limbs, and the latter variety in the growth of hydatids, etc.

In some varieties of insect life, as in the plant louse (Aphis), the process of internal budding is seen. The ovary of the mature female is actively engaged in developing buds, which assume the form of the parent, and becoming detached, descend the oviduct, and escape in the shape of living offspring. It is an easy transition from this perfect example of physiological budding to the phenomena attending the formation of new tissues of a separate individual in the various tissues of more complex living bodies.

Gemmation may be assumed to take place for the most part in the early history of the embryo, and at a time before the appearance of nerve-centres, and nerves which control and modify the processes of nutrition. Buds arising in the plastic tissues of the early stage of general development can fuse with one another, or split up into numbers of coequal parts, according to the retardation or activity of the nutritive processes themselves.

Gemmation in many lower animals is an act which may continue through life, but in man and vertebrates generally it is confined to the embryonic period.

A familiar illustration of a bud in the development of the human embryo, is the stalk of the optic tract. The pituitary body is a bud from the base of the brain. The origin of ducts of glands appended to the alimentary canal and the origin of the respiratory apparatus are also buds.

Buds may be assumed in general language to be synonymous with appendages. Thus limbs are the appendages of the trunk, and at the same time they are buds which spring from the trunk.

REMARKS.—In teratology numerous examples are presented by the operation of the law of gemmation. These may be divided into instances of external and of internal gemmation.

Internal Gemmation.	Dermoid Cyst.
	Fœtus by Inclusion.
External Gemmation.	Double Monster.
	Malformed Limbs.

Internal gemmation is illustrated in the dermoid cysts and in fœtus by inclusion.

Dermoid cyst. A number of cases are on record of tumors of the ovary, pituitary body or other parts, which were found to contain hair, teeth, mingled with horn, fat, and nerve-matter. They are thought to originate by a process of aberrant budding from those portions of the embryo in which they subsequently appear.[1]

Fœtus by inclusion. Fœtus by inclusion (fœtus in fœtu) includes those growths which contain portions of a second fœtus or embryo, in such manner that within a fœtus, which is in other respects normal, portions of a second individual exist. The tumors are met with in the scrotum, the heart, the lower end of the trunk, and even in the head, and are found to contain more or less complete parts of an embryo. The masses probably represent one individual of double monstrosity, which by some means has become subordinated to its stronger associate, and at an early period of development has been embraced by it.

It is well to state that in the judgment of some writers the presence of a tumor of the kind above described does not necessitate the process of a monstrous growth; but that even complicated organs are capable of developing themselves in parts of the body where normally they do not exist.[2]

[1] Corals, hydroids.

[1] See W. W. Wagstaffe, Trans. Path. Soc. Lond. xxix., 1878, 194.

[2] See Lebert, Traité d'Anat. Path., i.; and Foulis, Edin. Med. Journ., 1876, 839.—For the general literature of scrotal inclusion, see Vernenil, Archiv. Gén. de Méd., 1855, i.–ii.; A. Jacob, Dublin Hosp. Rep., iv., 1827, 571; Cruveilhier, Path. Gén. i. 370; W. H. Van Buren, N. Y. Med. Journ., ii., 1866, 355; W. Macewen, Glasgow Med. Journ., n. s., x., 1878, 433.

External gemmation is illustrated in teratology in the formation of portions of a second individual, which are appended to the main body—double monsters—or in the explanation of supernumerary limbs or parts of limbs.

Double Monsters.—The appended portions of a second individual embrace tumors which do not ordinarily contain the central cavities of the body, and which account for those peripheral structures, congenital in character, which contain bone, nerve, fat, etc., of a second fœtus.

A difference of degree alone exists between the class of tumors just denominated, and the presence of a fœtus or portion of a fœtus appended to the periphery of the body. In this way it is thought all forms of duplication of parts may be accounted for, whether the part be small, and not materially interfere with the usual outline, or be so pronounced as to give the expression of supernumerary limbs, portion of heads or trunks, or even an entire body, which is united to the main form by a narrow band or pedicle.

It is well to assume that each embryo possesses a separate yolk-sac or vitellus. If the tendency to duplication of parts extended from the blastoderm through the vitellus, two or more individuals could readily arise from a single ovum; a phase of generation commonly met with in many insects, in jelly-fishes, and related animals. Nothing similar to such division is, however, known to occur in vertebrated creatures. Twins are thought to arise from double conception, *i. e.*, the result of development in two separate eggs. Double monsters are often spoken of as "twins." The term "twin" is in this sense a convenient one only, and has no exact signification. A twin, strictly speaking, is one of two born at a birth. A double monster is a single individual, and as such arises from a single blastodermic membrane overlying a single vitellus.

Of all such united "twins," or nearly coequal duplicated persons, one individual is always the smaller. The larger frame will represent the main body, or, as the comparative anatomist would express it, the *parent-stock.*

Double monsters are of two kinds, those united along some part of the ventral aspects, and those united either by the crowns of the head or by the dorsal aspects. The normal head-fold, in place of forming a loop, uniting the medullary folds, may be incomplete, and permit the corresponding extremity of each fold to remain distinct.[1] Under some circumstances each fold will develop the parts of a perfect head, while the remaining portions will approximate and produce between them the dominating portions of a single individual. In this way a double-headed animal (Diprosopus, Dicephalus) may originate. Or the folds (separated by the lack of formation of the head-fold) may not tend to approximate, but remain distinct throughout their entire length, forming the basis of such forms of double monsters as Pygopagus.

In each of the foregoing examples, and in all intermediate forms, the vitellus remains unchanged. Hence, each portion of the egg, while presenting a double pair of parts, evolving the central nervous system and limbs, tends to have in common the organs of the chest and abdomen.

The malformations due to irregular formation of a single head-fold and adjacent parts will now be considered. Under the impress of some unknown trophic condition the head-fold or medullary folds develop atypically.

The head-fold may fail to unite the two medullary folds. Under this condition the latter do not approximate. A group of modifications based upon the above follow where the folds may approximate and join, and from the point or points at which they do so the parts of a single individual arise. Thus, if the folds remain distinct throughout their entire length, the embryos are united by their ventral surfaces only, and have more or less of the imperfectly divided abdominal and thoracic chambers in common. But at the points of embryonal contact of the medullary folds there exist, in addition to the great visceral chamber, a single back-bone and central nervous system (Thoracopagus). In one of the most remarkable examples of double monster on record—the Siamese twins—the bond of union was much smaller than is ordinarily seen. But its position was strictly ventral, and contained hepatic tissue which seemed to unite the two livers. It follows that the proper position in which to study a specimen of united twins of this kind, is face to face, no matter what the position acquired during life may have been. One umbilical cord and placenta are present.

The head-fold may be normal, while the medullary folds fail to approximate, and each one develops a separate individual; the result is a single-headed two-bodied individual, forming the basis of such forms of double monster as Pygopagus (Synencephalus).

The medullary folds may be joined for the greater part of their length.

[1] This has been observed by Prof. S. F. Clarke in the Ambystoma punctata, a fresh-water salamander of the United States.

The folds may unite at the posterior ends only so as to exhibit the parts of the pelvis in common (Pygopagus).

Each of the above malformations has but a single umbilical cord.

As in the case of duplication of parts joined at the head an attempt at rotation is surmised to have occurred, so in the remaining varieties the relative positions of the two individuals can be explained by referring to the same tendency on the part of one or both embryos. The cause of the rotation would appear to be the contraction of the yolk-mass. This, of necessity, takes place toward the abdomen; and the contraction toward the abdominal space of a double embryonic mass, it is assumed, may change the position of the individuals. If the individuals are free in front, but fixed behind, the contraction causes irregular attempts at rotation to occur about the fixed point. Thus the anterior ends of the two trunks will either turn slightly away one from the other, and will place the heads in a position with the occiputs opposed, or they will so far diverge as to place themselves in the same line. If the embryos are united at the middle of the trunk the bodies remain variously fixed at the thorax and abdomen, being fixed at the thorax and abdomen in such wise as to cause the body to behave to the yolk as that of a single individual, and no material change of position of the free parts is practicable.

Malformed Limbs. The limbs may be looked upon as buds or peripheral outgrowths from the trunk. It follows that in an arrest of development the proximal portions will be rudimentary or absent, while the distal parts may be perfect. In this way stunted limbs with well-developed hands or feet projecting near the trunk are formed.

Excess or diminution of the number of toes or fingers is of relatively frequent occurrence. The excess is ordinarily an example of peripheral budding, while the diminution is a restriction due to some deep-lying cause affecting the tarsus or carpus of the individual. It may be held as an axiom that the carpus and tarsus determine the form and arrangement of the fingers and toes. Every description of a specimen of malformation of the hand or foot should be accompanied by an account of the dissection of the carpus or tarsus.

It has been already seen that supernumerary fingers or toes are, as a rule, examples of peripheral budding. They may be held to be such when they do not involve the carpus or tarsus; but when they involve these structures their origin may be traced to some malformation of central instead of peripheral marginal elements. Thus, instead of the first or fifth finger being duplicated, the third may be increased in size—the supplemental third finger involving the carpus between the os magnum and the trapezium. It is evident from such a description that a mere superficial examination of the limbs would give no clue to the nature of the defect. Neglect of this simple precaution has led to much confusion in the description of defects of the hands and feet, notably in those instances where attempts have been made to explain malformations of excess by reversion to some partially obliterated ancestral tendency.[1]

(2) PARTS WHICH ARE ARRANGED IN SERIAL ORDER.

The presence of a congenital defect in one portion of the vertebral column should induce the observer to make careful examinations of the entire vertebral series, including the bones of the cranium, as far forward as the body of the ethmoid bone. The central nervous system should also be inspected when this is practicable.

The manner in which the sternum develops suggests that an attempt is made in this bone for the several centres of ossification to be arranged in serial order, and in pairs. This arrangement is subject to much modification, but sufficient data exist to warrant the conclusion that a deformation in a portion of the sternum coexists with some minor variation or defect in another portion, and that the entire bone is more or less unusually formed.

The parts arising along the lines of the visceral arches are liable to malformations which embrace the entire development of the arch and often of related parts. (See p. 770.)

Exaggeration of the oral fissure (Macrostoma) is not a single malformation, but, as found by A. Thompson,[2] is associated with defects of the auricle, and atrophy of the lower jaw. In a case of cleft palate, recorded by E. Home,[3] the lower jaw was abortive, and the external meatus narrowed.

The teeth are closely related structures whose variations conform to the rule that the malformations of serial homologous bodies are related one to another. (See p. 633.)

[1] See Otto, Monstrorum sexcentorum descript. Anat., tab. xx.–xxvi.; Musée Dupuytren; Ammon, Die angeborenen Chir. krankheit. der Menschen, Berlin, 1840, tab. xxii.; Meckel, Archiv für Anat., xxxvi.

[2] Edin. Monthly Journ., vii. 1874.

[3] Phil. Soc. Trans., lxxx., 1790, 175; also Ibid., lxxxix., 1799, 189.

(3) IN ILLUSTRATION OF THE LAW OF REVERSION.

A malformation or variation which exhibits features recalling the normal arrangement in some lower animal is said to illustrate the law of *reversion*. In the human subject reversions are confined to the class of vertebrata, and most commonly suggest the disposition of parts in terrestrial mammals. Many examples have been cited in this book of such reversional variations.

It will be appreciated that a knowledge of comparative anatomy is essential to a correct interpretation of many unusual features in the anatomy of the body.—It is interesting to note that some variations in illustration of reversions (especially in the bones), are peculiar to the aged. While many of the instances of reversion are also those of gemmation, the last instance noted is in marked contrast to such similarity. In the aged, varieties of reversion may be acquired after all active life processes are arrested or in a state of pathological change.

The presence of a large bone in the septum pectiniformis of the penis of many animals would lead the observer to seek for a rudiment of the bone in the septum as it exists in man. J. von Lenhossek[1] has described true osseous growths in the sheath of the cavernous bodies.

(4) IN ILLUSTRATION OF THE LAW OF SYMMETRY.

The disposition existing in the body for many parts to be arranged in pairs is capable of being modified. While geometrical symmetry does not exist between any of the organs of the body exceptional contrasts in volume and proportion naturally come within the scope of teratological studies. Under the operation of the law controlling the position of the organ may be conveniently placed all studies of *transposition of the viscera*.

One of the objects of symmetry is to secure periods of rest in organs of the same nature. Thus the right kidney is at rest when the left is active, as has been observed by Erichsen in studying cases of extrophy of the urinary bladder. It is of interest, according to O. Beumer,[2] to note the increased liability of subjects of single kidney to calculus of the pelvis of the kidney.

[1] Virchow's Archiv, lx., 1874, 1; Taf. 1. [2] Ibid., 1878, 344.

Rates of Growth as affecting the Origins and Behavior of Aberrant Structures. The rates at which the different portions of the embryo grow determine, of course, the order of the appearance of the several parts. When a structure appears at a period earlier than is usual, the rate of growth is said to be *accelerated;* or, per contra, when later than usual, to be *retarded.* Examples of acceleration are often spoken of as *precocity*. Instances of acceleration and retardation of a gross character are rare; the order of the rate of eruption of the teeth, and the union of epiphysis to the shafts of bones may be taken as illustrations. Acceleration and retardation may explain some of the variations of bloodvessels (see pp. 337, 395).

Retention illustrates a structure ordinarily transient in character, which remains as a part of the permanent structures of the embryo. Thus the *ductus arteriosus* remaining patulous at a time when, according to the average experience, it should become impervious, is an example of retention. Some of the characters of the skeleton of the adolescent sometimes will persist in adult life when they constitute the so-called retention of "juvenile character." In like manner the "infantile uterus" is sometimes found in the adult. Retention is also used to express the fact that a tooth which is retarded in development is *retained* entire within the structures of the jaws.

The general subjects of *aplasia* as illustrated in the study of dwarfs, and of *hyperplasia* as illustrated in the study of giants, come under the head of acceleration, retardation, and retention.

Structures retarded in development, or which remain in vestigial form beyond the period at which they are normal, are apt to yield to diseased action. Instances of this tendency are noted in the diseases of the remains of the thymus gland; in the diseases of the imperfectly developed or retarded wisdom-tooth; in the diseases of the structures entering into spina bifida and encephalocele; in the diseases of the imperfectly descended testis; and in cystic tumors originating in the hydatid of Morgagni. Since the prostate gland retains the rudiments of the terminal portions of the Müllerian ducts, as well as the associated matrix of the genital cord, the enlargement of this gland at times, when the dominating control of the sexual element in nutrition is being removed, may be in like manner explained by an aberrant acceleration occurring in a vestigial structure.

ON MAKING POST-MORTEM EXAMINATIONS.

THE following rules for conducting post-mortem examinations will be found useful:—

The abdomen should be examined first. To effect this, a free incision should be made in the median line from the xiphoid cartilage to the pubis, care being at the same time exercised to shield the intestines from injury. In incipient decomposition the coils of small intestine lie closely apposed to the anterior abdominal wall, and will be liable to injury if the latter be not lifted from them, or a director slipped beneath the parietal peritoneum before the final section is effected. A transverse incision should next be made which will pass either immediately above or below the umbilicus. The four triangular flaps made by the above incisions may now be turned outward, the abdominal muscles divided from within outward, and the flaps turned over on the trunk. The abdominal contents, after being observed in their relations one with another, and with the trunk, may be examined in the following order:—

1. The peritoneum including the great omentum, the jejuno-duodenal fossa, the pelvic folds, hernial protrusions, etc.

2. The small intestines (after the portal vein and its tributaries have been examined) may be secured at the beginning of the jejunum and at the end of the ileum by double ligatures (the gut being divided between them), and the mesentery boldly cut through. If no immediate interest attaches itself to the small intestine, the mass may be placed in water and examined at the close of the autopsy.

3. The genito-urinary apparatus should next be examined, extending in observation from above downward. The supra-renal capsule is here included for convenience.

4. The spleen, stomach, duodenum, pancreas, and liver next claim attention. These structures have intimate topographical and clinical relations. The colon being left in position is of importance, since many of the lesions of chronic disease, especially of the epigastric and hypochondriac organs, involve the shape, size, position, and not infrequently even the integrity of the colon particularly at its transverse portion. The liver should be left to the last, because of the important relations it sustains to the Diaphragm. The Diaphragm is not to be disturbed, or the thorax opened, until the abdominal organs have been satisfactorily studied. This practice is advised, not because the mere removal of the upper abdominal organs would of necessity affect the arch of the Diaphragm, but because of the chances that it may do so. The almost inevitable dragging on the Diaphragm during the removal of the liver may cause the lungs to expand, and a false conclusion thus be arrived at respecting the ante-mortem condition of these organs, while a mere accidental puncture through this tense tendo-muscular septum will cause the entire structure to become flaccid, and the condition of the base of the pleural cavities, and of the lower part of the pericardium as it existed during life to be irrevocably destroyed.

In removing the liver from its bed the lateral ligaments should be first divided, the hand (with palm down) should next be thrust between the Diaphragm and the liver, and the former thus peeled from the latter. The organ should be isolated from all topographical relations, and held by the organic only, namely those found in the lesser omentum. This important band should not be divided until after the duodenum and pancreas have been studied. In the above description it is noticeable that the knife is used only in dividing the lateral ligaments and the lesser omentum; all other connections can be removed with the fingers. The Spigelian lobe is thus saved intact, the free use of the knife from above downward often resulting in the mutilation of this lobe.

For the simple examination of the stomach a longitudinal section of the anterior wall will suffice. The organ should be removed by separating the Diaphragm from the œsophagus and dividing the latter as high up as can be done without destroying the Diaphragm. The lower end should be preserved intact by dividing the ascending portion of the duodenum.

This procedure preserves the lesser curvature of the stomach and the exact position of the pyloris.

The duodenum and pancreas can be examined together. The first-named may be opened in continuity with the stomach by an extension of the same incision. Should it be deemed advisable to remove the organ, such removal is to be reserved until after the examination of the spleen is finished. The pancreas and the duodenum are in part retro-peritoneal, and their relations with the kidneys, thoracic duct, sympathetic ganglia, and bloodvessels should be sought for.

The spleen is best removed by seizing it with the hand, and drawing the vascular pedicle (holding it to the cardiac end of the stomach) until such structure becomes tense, when it should be divided by the knife or scissors.

The pancreas and duodenum still being in position, and the liver held to its physiological relations by the lesser omentum, and its contents remaining intact, the condition of the biliary and the pancreatic ducts should be observed, as well as that of the portal vein. Lesions of the hepatic or other branches of the cœliac axis of vessels are so rare that the observer may be excused examining this condition in other than in obscure disease, referable to its branches.

The Biliary Ducts. The examination of these is of great importance. In the language of Virchow,[1] "the papilla of the ducts of the liver and pancreas should be examined and its contents gently pressed out; then by pressing on the gall-bladder, we should determine the presence or absence of obstacles to the flow of bile; and, lastly, the ductus communis choledochus should be slit up." "It is quite useless to pass a probe along the gall-duct, for our being able to introduce a probe into the orifice is no evidence whatever that the intestinal (mural) portion was pervious during life."

A final word of warning must be given before the abdomen is left. If the centre of attraction is the autopsy centre about the heart, or of a condition of which the heart and liver are or have been important agents, the above account of the examination should be so far modified as to enable the operator to retain the liver in position until the thorax has been opened and the heart examined. It is very evident that the removal of the liver will, by severing the hepatic vein, cause the inferior cava and possibly the right side of the heart and superior cava to empty a portion of their contents into the abdominal cavity, and the exactness of a subsequent observation on these parts thus be lost. It is true this misadventure can be prevented by ligation of the hepatic veins before the ablation of the organ. But such an operation is tedious.

The order of examination of the abdomen, as recommended by Virchow,[1] is as follows:—

(1) The omentum.
(2) The spleen.
(3) The left kidney, supra-renal capsule, and ureter.
(4) The right kidney, supra-renal capsule, and ureter.
(5) The bladder, prostate gland, vesiculæ seminales, and urethra.
(6) (*a*) The testicles, spermatic cord, and penis. (*b*) Vagina, uterus, Fallopian tubes, and ovaries, etc.
(7) The rectum.
(8) The duodenum and intestinal portion of the ductus communis choledochus.
(9) The stomach.
(10) The hepato-duodenal ligament, gall-ducts, vena portæ, gall-bladder, and liver.
(11) The pancreas and semilunar ganglia.
(12) The mesentery, with its glands, vessels, etc.
(13) The small and large intestines.
(14) The retro-peritoneal lymphatic glands, receptaculum chyli, aorta, and vena cava inferior.

In the event of an abdominal incision being impracticable, it is well to know that not only the pelvic organs, but all the abdominal organs, can be removed *per vaginam*. The liver alone would have to be divided with scissors before removal.

Thorax. Virchow[1] has given the general direction that, after the abdomen is opened and the general relations of the organs made out, the thoracic organs should be next studied *in situ*. In a word, all the *relations* of the organs in both great visceral chambers should be ascertained before proceeding to the dissection of either. If ordinary care be taken concerning the wounding of the Diaphragm, or the escaping of blood from the larger veins, the thoracic relations need not be of necessity disturbed. The preservation of the arch of the Diaphragm—its height—its relations to the liver and the chest-wall, however, *must* be made out before the thorax is opened. No case of hepatic abscess, peri-hepatitis, diaphragmitis, pleurisy, pericarditis, ascites, peritonitis, not to mention wounds and fractures of the ribs, can be satisfactorily studied un-

[1] R. Virchow, Method of Performing Post-mortem Examinations. Trans. by T. P. Smith.

[1] L. c., p. 22.

less the post-mortem examination of the Diaphragm be made accurately before its points of insertion, or the pressure to which it had been subject during life, had been disturbed.

To open the chest an incision should be made, extending from the centre of the inter-clavicular space downward to be continuous with the abdominal incision. The skin is quickly turned to either side by long sweeping cuts of the knife, the edge of which should keep close to the chest-wall, and expose the ribs at every stroke; the cleaner the exposure, the easier becomes the work of preparation for opening the chest-wall. Upon approaching the false ribs, the upper flaps, already made from the abdomen, should be held up, and the knife made to divide the slips of origin of the oblique muscles, so as to leave the lower ribs as clean as the upper. If the subject be young, the costal cartilages may be divided by a stout knife or costatome, immediately to the inner side of the sternal ends of the ribs, and a transverse section joining the longitudinal ones, about the line of the middle of the second costal cartilage. The last-named line will sever the manubrio-gladiolar junction. If, however, the parts mentioned are ossified, the saw must follow the lines of the incisions as given. Ordinarily, the saw is used for dividing the cartilages, and the knife for dividing the sterno-clavicular articulation.

The procedure of severing the attachment between the clavicle and the sternum is best effected as follows: Divide the first costal cartilage by an oblique incision from below upward and inward toward the under surface of the joint. This allows the knife to enter the joint at the lower edge of the sternal facet. Care should be taken to avoid opening the innominate vein. In opening the joint from above, more especially if the first costal cartilage be not first divided, the vein is often entered by the incautious use of the knife. The escape of blood into the pleural cavities is always unfortunate. The pleuræ become smeared with blood, disguising their true appearance, and the serous fluid is lost.—Sawing through bone (either of rib or sternum) should be avoided when possible. If the section with the saw is compulsory, the edges should be covered with towelling to protect the hands of the operator.

Littlejohn[1] has advised that, before the Diaphragm is raised, after the costal cartilage and diaphragmatic attachments have been divided, "the hand should be passed up into the anterior mediastinum, breaking up the connective tissue, and exposing to the touch the organs as high as the root of the neck." This procedure frequently enables the operator at once to discover the probable cause of death. Any tumor, whether aneurismal or otherwise, is readily detected, and some general idea obtained as to the size of the heart and of the condition of the lungs. Nothing can be more embarrassing than to mutilate an aneurismal sac in removing the sternum; whereas, the existence of a swelling in the neighborhood of the aorta having been ascertained, greater care is exercised in separating the sternum, and the diseased structures are exposed in an uninjured condition.

The organs should now be described *in situ*.

The Lungs. It is not necessary to remove the lungs in order to examine them. If the object of the examination be to ascertain the general appearance of the parenchyma and pleura, the root of the lung need not be disturbed, but using it as a fixed point, the lung can be raised from its position and (by inserting a towel or large sponge in the pleural cavity) the organ can be thrown up above the plane of the body, placed thus in a good light, while such section or measurement is made as may be thought necessary.

The Heart. The heart, from the delicacy of its mechanism, the complexity of its several parts, and the great importance frequently attached to its examination after death, is to be studied with great care, and the necessary section to explore its interior is to be made with precision.

After the pericardium is opened, the serum therein contained should be removed by a syringe and measured. The same instrument should be used in withdrawing any fluid from the body, rather than a sponge, which is of necessity a much less accurate aid. Each chamber of the heart should be opened separately, but in such manner as to cause the least amount of injury to the valves, septa, and the orifices of the veins and arteries.

The incisions proposed by Virchow (l. c., p. 36) are as follows:—

For Right Auricle, beginning half way between the planes of entrance of the venæ cavæ, and ending just in front of the base.

For Right Ventricle, beginning close to the base and carried nearly, but not quite, to apex; if carried too far toward the apex, the septæ will be injured.

For Left Auricle beginning at the left superior pulmonary vein, and ending in like manner just in front of the base, which is usually indicated by the very prominent coronary vein. The coronary veins should be carefully avoided.

[1] Edinburgh Med. Journ., 1876, 1113.

For the Left Ventricle, beginning behind the base, and ending short of the apex.

In making the incisions on the right side, the heart is held in the left hand, and rotated toward the left, so as to bring the right lateral border uppermost. In making those of the left side, the heart is seized toward the apex, drawn inward and to the left, while the thick close-set lateral wall is caused to bulge out by gentle pressure.

After the blood has been removed from the cavities and examined, the heart is severed at its base by dividing the great vessels, a fair distance from the heart, and the pulmonary arteries and veins at the roots of the lungs.

After removal, the capacity of the ventricles and the accuracy of closure are approximately determined by pouring water downward into the auricles and great vessels.

This is a reasonably accurate test for the semilunar valves, since they are normally closed by the recoils of the blood sent into the pulmonary artery or aorta, back against the cups of the valves. For the auriculo-ventricular valves, however, it is necessarily imperfect, since the force of the water does not imitate the normal act of closure, which is intricate, and cannot be performed apart from the living organism.

The sections for the study of the valves are selected by following the lines of the natural passage of the blood. Incisions should be made with care through the anterior wall of the right ventricle to avoid injuring the anterior papillary muscle, the moderator band, and the small septal leaflet of the tricuspid valve.

In opening the left auriculo-ventricular valve, it should be remembered how distinct its axis is as compared to that of the right side, and that one of the leaflets of the valve lies close to the septum, and may be injured by incautious adherence to a line too near that structure. By inserting the finger from the right ventricle upward along the pulmonary artery or from the left ventricle along the aorta until the anterior of the three corpora aurantii is felt, a pair of blunt-pointed scissors may be passed along the finger and the valve be divided without liability of injuring the leaflets.

In the event of disease involving the entire respiratory tract, or when the lesion is one requiring careful dissection of the parts at the base of the heart or the root of the lung, the best plan of procedure, after the organs have been carefully studied in position, and surrounding circumstances favoring, is to remove the thoracic viscera *en masse* inclusive of the trachea, larynx, and hyoid bone. This can be easily effected by making a vertical incision through the skin along the median line of the neck (the sternum having been previously removed), and the soft parts roughly dissected to the sides. A transverse incision is now made above the hyoid bone downward to the vertebral column. The trachea is next seized with the left hand and pulled downward toward the thorax, the knife being held in the right hand in order to divide the vessels at the root of the neck as they become tense under the downward strain. Below the position of these vessels no obstruction exists to the easy separation of the aorta and other parts from the front of the vertebral column, and the evulsion of the entire contents of the thorax over the abdomen is soon accomplished. The removal of the various points of attachment is soon accomplished, and the organs can be placed aside in a preservative fluid for detailed study.

In rupture of the arota into the pericardium, when the orifice is so small as to escape notice, it is recommended by Littlejohn[1] to incise the left ventricle and pass the forefinger of the right hand into the aorta. "As the ruptured orifice is generally situated anteriorly, by simply pressing the finger against the wall of the vessel the slightest depression is detected, and then, on closer examination, the minute rupture is detected. Should any doubt remain, the aorta may be compressed at the arch, and some water injected upwards from the ventricle, when a tiny jet will quickly determine the site of the aperture."

The Brain. This is examined after the abdomen and thorax. If it be examined first, the escape of venous blood from the sinuses will drain venous blood (particularly if the head is allowed to remain pendent from the edge of the dissecting table, as is often the case) from the venæ cavæ and heart. It is evident, however, that the reverse of this proposition is true, and if in the judgment of the operator the condition of the parts in the skull be of greater importance than those of the trunkal cavities, there can be nothing to oppose, but, on the contrary, everything to favor the examination of the head before opening either the abdomen or the thorax.

To examine and remove the brain the sections must be as follows: With a sharp knife the operator should penetrate the scalp over the ear, and, keeping the point upward, cut the scalp from within outward, while the section is made toward the vertex, and from that region downward to the ear of the opposite side.

[1] Edinburgh Med. Journ., 1876, 1116.

In this manner the scalp is divided from ear to ear (the hair being but little injured), and forms two flaps which can be easily retracted to expose the skull. The skull should now be sawed in such manner as to make a circular section round the head, a little above the ear. To avoid the inconvenience of using the saw at the occiput, upon which point the weight of the skull rests, some physicians confine the circular incision to the frontal and temporal regions, and join its ends by an oblique rim extending upward and backward between the occipital protuberance and the lambdoidal suture. There can be no objection to the latter section where removal of the brain is alone intended. It has, indeed, the advantage of holding the skullcap in better position than when the circular incision is employed. The incision first named is to be preferred when the brain is to be studied *in sitû*, and the skull preserved. Neither should there be any difficulty in readjusting the round-based skullcap. Hard wooden pegs, or, what is perhaps better, iron brads, can be driven in the diploë of the occipital and lateral parts of the frontal bone, and the free projecting ends sharpened to a point. The skullcap can be fitted thereto by placing the ends of the pegs or brads in the diploë, and firmly forcing the skullcap downward. Dr. Chas. K. Mills[1] recommends, in making the section which will expose the brain-case, that the Temporal muscle-fibres be left on the skull-cap, as a few stitches through the divided ends of the muscle assist materially in holding the skull-cap in position. The saw need not pass entirely through the skull. A few strokes of the hammer on the chisel of the post-mortem set will suffice to sever the inner brittle plate. It is, perhaps, unnecessary to point out the fact that the skull is thinner at the temporal region than elsewhere, and is least thin at the occiput. The incautious operator may injure the brain at the former point long before he has reached the inner plate at the latter. The dura mater may be cut through along the line of the section made by the saw, and thus, should it be adherent to the skullcap, may be removed therewith, the scissors being used to divide the points of union with the great longitudinal falx. It has been advised, especially in the autopsies of children, to saw through both bone and brain together, in cases where the study of the form of the brain is a matter of little importance. After the skullcap and dura mater have been removed, and the pia mater exposed, the condition of the bloodvessels should be studied with care, and both sides of the pia mater examined. The base should not be disturbed until the condition of the superficies, corpus callosum, and the quantity of fluid in the ventricles have been ascertained. Removal of the brain under the most favorable circumstances lacerates the already softened structures. Even in the normal brain, the falling outward of the cerebral hemispheres (now no longer supported by the sides of the skull and falx) will sever the middle commissure of the third ventricle. The brain, while yet in position, will permit the lateral ventricles being opened by a vertical section made a half inch to the outer side of the great longitudinal fissure downward to the lateral ventricle, which being thus opened, a syringe furnished with a long nozzle may be used to withdraw the fluid.

In suspected fracture of the cranium, special care must be taken to avoid the blows of the mallet in any way complicating the lesion. The same writer advises that the saw should never pass further than fairly into the diploë, and whenever practicable the so-called inner plate be left intact. Instead of the mallet and chisel, he recommends that the chisel alone be used. "A stout piece of steel is loosely fitted by an aperture to the chisel edge, and, gravitating by its weight, is arrested at the shoulder of the instrument, thus forming a cross where the two portions are adjusted. By sawing deeply over the frontal sinus, the sharp edge of the chisel is easily inserted; and by simply turning the chisel round, the internal plate at once gives way with a slight crack, and the skullcap is felt to be detached."

The interior of the calvarium should be carefully examined for evidence of fracture.

In removing the brain the anterior portion of the cerebrum should be gently raised and all the cranial nerves be severed at their points of exit through the floor of the brain-case. The tentorium is next slit from side to side, and the medulla oblongata severed from the spinal cord by making an oblique cut with a long knife as far down in the vertebral canal as is possible. The pituitary body, by a *tour de force*, can be removed with the brain, the pedicle remaining intact. Ordinarily, however, this body is left in the pituitary fossa. The brain when removed should be placed base upward in a shallow vessel with curved sides, such as a tin wash-basin, to avoid the falling outward of the hemispheres. Perhaps the best plan is to invert the brain in the skullcap, and place the latter top downward in a towel folded loosely in the basin. Prof. Burt G. Wilder recommends dividing the brain longitudinally in the median line, and placing the

[1] Phila. Med. Times, 1880, vol. x. 365.

median surfaces downward upon the bottom of a flat dish. The subsequent examination of the brain must be conducted according to the immediate object in view. Indiscriminate slicing of the organ is to be avoided. If the intention is to determine the general condition of the parts without reference to any minute study of the texture of the organ, the examination may begin by exposing the lateral ventricles. The incisions made as above recommended to expose these cavities with a view of collecting the fluid, manifestly cannot be made to any advantage after the brain has been removed from the head. Conceding, therefore, that such incisions have already been made, a narrow knife is next passed through the foramen of Monro, and the corpus callosum and the fornix divided transversely. These parts are turned back in order to display the cavity of the third ventricle. The horns of the lateral ventricle can be slit up by an incision extending along their entire lengths. The velum body and the pineal interpositum are next examined, the greatest care being required—owing to the intimate association existing between it and the fibres of the velum—to preserve the pineal body uninjured. A director is next passed along the communicating passage between the third and fourth ventricles, and the superimposed tissue divided. The cerebrum is next usually sliced from within outwards in crude imitation of the compartments of an orange, viz., each section being narrow toward the lateral ventricle, but wide toward the outer surface. The object of such treatment is to examine carefully for alterations of a morbid character, and to permit the different compartments or divisions to be examined at will and returned to their natural relations. This method further aids the preservation of the tissues by permitting the selected fluid to permeate through the entire thickness of the cerebrum. To display the relations of the nuclei of the striated body one to another and to the cortex horizontal sections may be made in the manner used to demonstrate the arbitrary planes of the cerebrum, viz., the lesser and greater oral sections. In the language of Dr. Mills (l. c.) the cerebrum may be divided, according to the method of M. Pitres (see p. 508), as follows:—

"The first incision is made through the præ-frontal region, the second, through the bases of the three frontal convolutions, the third, through the ascending frontal convolution, the fourth, through the ascending parietal convolution, the fifth, through the superior and inferior parietal lobules, and the sixth, through the occipital lobe. The incisions should be made in each hemisphere from within outwards nearly to the convolutions.

"Instead of the vertico-transverse, the vertico-longitudinal section may be used. In this method beginning at the cerebral peduncles, smooth incisions long and deep enough to expose all the parts to within a few lines of the convolutions of the base should be carried through both optic thalami and corpora striata and out into the hemispheres, a few extra sections being made in the white matter above the level of the ventricles.

"It may sometimes be desirable to examine the interior of the cerebrum from the base, which can be readily done, particularly if a fair knowledge on the part of the operator is possessed of the relations of the fissures and convolutions of the surface to internal eminences and cavities."

The Spinal Cord. The spinal cord can be removed with advantage as follows: After severing the laminæ of the vertebræ by the saw or with pliers, sever the dura mater and the cord at the level of the foramen magnum. The membranes and the cord at the plane of this section are then lifted together from the vertebral canal, the nerves, and the filum terminale being successively divided, the entire cord with the membranes are removed. The dura mater and the pia mater may then be slit and the surface of the cord inspected; subsequently the specimen may be divided in sections of convenient length and immersed in an appropriate preservative fluid.

The Ear and Nasal Chambers. To the student of nasal and aural diseases it often becomes desirable to remove the nasal chambers and the ears for special study. Schalle[1] has written an elaborate paper descriptive of a process original with himself which is undoubtedly the best that has yet been offered to effect this object. The essential feature of his method is the removal of all the parts of interest, which cannot be inspected upon the undissected body, and the securing of such without mutilation of the features, or the making of unsightly seams.

After removal of the skullcap and the brain, as already described, a trifoil-like figure is traced upon the floor of the brain-case so as to include in the anterior leaflet the anterior part of the basilar process of the occipital bone, the body and basal portions of the greater and lesser wings of the sphenoid bone, and the inner halves of the orbital plates of the frontal

[1] Virchow's Archiv, vol. 71, 1877, 206, Pl. ix. The plate displays the line to be followed by the saw, a figure of the parts removed, and of the instruments employed.

bone (inclusive of the cribriform plate of the ethmoid), while the petrous portions of the temporal bone lie in the lateral leaflets. The junction of the anterior leaflet and the lateral leaflets is secured at a point answering to the bottom of the glenoid fossa, which in the brain-case answers to a point at the base of the petrosal eminence at the lateral half of the middle cerebral fossa. It is to be understood from the onset that a section of the skull the shape and size of the trifoil figure is to be removed by vertical section. The essential feature of the procedure is to insert a narrow saw-blade of a bow-saw through an opening made through the middle cerebral fossa at the point indicated, and the section made by sawing out vertically the pattern of the trifoil.

The plan being thus understood, Schalle begins the dissection of the parts outside the brain-case as follows:—

An incision is made with a stout scalpel over both clavicles, from one acromial process to the other. The head and neck are next made to fall by a shoulder-block being thrust beneath the scapula, and the incision continued upward, along one side of the neck to an inch and a half above and behind the external auditory meatus, and is here made continuous with the transverse incision across the vertex already made for removal of the skullcap. It now descends on the opposite side of the neck, and meets the acromial end of the first trans-clavicular incision. This long and bold cut can be well covered subsequently by the clothing, and permits of free manipulation of parts lying between the limits of the incision, both in front and behind.

The anterior flap is turned down over the face to the brows, and laterally, by free incision through the cartilaginous external auditory meatus, to over the cheeks. Next the anterior flap is raised from the clavicles to the lower jaw. The structures of the supra-hyoid region, viz., the Genio hyoid, Mylo-hyoid, Hyo-glossus, Genio-glossus, and D gastric muscles, the facial arteries, etc., are divided, and the tongue drawn down and out of the mouth upon the neck. The palato-glossal and pharyngo-glossal connections are next divided, the pharynx severed about on the level of the aperture of the larynx, and the entire hyoid apparatus with the tongue pulled toward the sternum, thus leaving a free space for manipulation upon the under part of the skull. The Pterygoid muscles are now separated from the lower jaw, the temporo-maxillary articulation opened from within, and the lower jaw drawn forward, so as to rest upon the articular eminence in advance of the glenoid fossa.

The molar teeth in the upper jaw are now extracted to avoid the resistance they would offer to the action of the saw.

The posterior wall of the pharynx is next removed from in front of the vertebral column, and as far as possible from the roof of the pharynx. All the space needed is secured. It is now necessary to fix the lower jaw in its forward position at the chin, and to steady the skull while the bottom of the glenoid fossa is perforated to permit the use of the saw, which is made to perform a circuit, cutting out in the shape of a trifoil-cylinder the cavity of the nose and both petrous portions of the temporal bone. The saw should pass between the crista galli and the foramen cæcum in front, close to the squamous portion of the temporal bone at the sides and about midway between the foramen magnum and the occipito-sphenoidal junction, behind.

When the section is complete it can be removed from above by gentle pressure on the hard palate. The specimen will not include the anterior half of the superior maxilla, the anterior ethmoidal cells, the anterior part of the inferior turbinate bone, the interior of the external nose, nor the outer posterior part of the mastoid process. These should, therefore, be carefully inspected in the cadaver before closing the parts.

To effect the latter the lower jaw must be readjusted to the portion of the glenoid fossa yet remaining in position, the tongue and hyoid apparatus replaced. The brain-case is filled with some light absorbent material, such as sawdust or oakum, and the remains of the eyeballs pushed outwards—since the section has, of necessity, included part of the orbital contents. The skullcap is restored in the ordinary way, and the skin-flaps readjusted. This manipulation appears at first sight laborious, and would doubtless prove so to a tyro. To one accustomed to the use of instruments no great degree of difficulty need be anticipated.

It is likely that the use of the dental engine, in lieu of the bow-saw, would greatly facilitate making the section.

Foulis[1] advocates an examination of the middle ear by splitting the petrous portion of the temporal bone with a chisel along a line parallel to the squamous plate, directly to the outer slope of the eminence caused by the superior semicircular canal. The tympanum is opened by this procedure, as well as the mastoid cells, while the stapes is usually separated from the incus. Should a particular examination of

[1] British Med. Journ., April 24, 1880.

the inner ear be desired, the loose bits of the "petrous bone" might be again divided in various directions according to the demands of the case. This method, while confessedly crude, may be of some value where circumstances do not permit of more systematic exploration.

The Eye. The removal of the eye, when it is not deemed important to extirpate the entire globe, can be easily accomplished by breaking through the brittle orbital plate, and dividing the eyeball transversely immediately behind the corneo-scleral junction. The eyeball, thus mutilated, is then lifted from its bed, the insertion of the peri-ocular muscles divided, and the nerve severed.

The Bones. It often becomes necessary to saw the long bones longitudinally. The selected bone should be fixed in a vise, and the section made by the ordinary saw of the post-mortem case. If a gig-saw be available, especially one run by steam-power, the operator will save much time and trouble by securing the assistance of a workman skilled in the use of such a machine. The section by this means is made with great celerity and precision in any desired direction.

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